Reconnaissance Investigation of Sand, Gravel, and Quarried Bedrock Resources in the Yakima 1:100,000 Quadrangle, Washington

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INTRODUCTION

Background

During its 1998 session, the Washington State Legislature, acting on a recommendation from the Governor's Land Use Study Commission, asked the Washington Department of Natural Resources (WADNR) to map gravel and bedrock resources that could be used for maintenance and construction of homes and infrastructure. The Study Commission sought this information to assess the need to protect these resources from urban sprawl and other intensive land uses. These data would, in turn, result in better long-range planning and possible legislation to aid in designating mineral resource lands under the Growth Management Act (Revised Code of Washington [RCW] 36.70A; Lingley and Jazdzewki, 1994).

Although the data are presented here in the traditional text and map format, this report is part of a project to prepare a geographic information system (GIS) database that delineates the location of some of the significant construction aggregate resources (sand, gravel, and quarried bedrock) of Washington State. The digital version of this report, including ArcInfo coverages, is available through the Washington Division of Geology and Earth Resources *(see back of title page for address)*.

The Yakima 1:100,000 quadrangle is located east of the Cascade Range in south-central Washington from 46.5 to 47 degrees north latitude and 120 to 121 degrees west longitude (Fig. 1). Approximately one-third of the quadrangle is in Kittitas County, while the other two-thirds are in Yakima County. The population of the quadrangle is approximately 150,000, with the largest population centers at Yakima (population ~66,000) and Ellensburg (population ~15,000). The population of Kittitas County is about 33,000 and Yakima County is about 213,000 (Washington Office of Financial Management, 2000).

Intended Audience

This inventory was created primarily for use by local government planners to help refine comprehensive plans and other zoning determinations. It will also aid legislators and other policy makers in assessing the importance of largely nonrenewable sand, gravel, and quarried bedrock resources. The study should also benefit engineers, transportation departments, and industry.

Primary Products

This inventory includes the following products:

1. Databases containing the location, thickness, quality, and volume of some sand, gravel, and bedrock resources (Appendices 3–5).
2. A map showing the probable extent of bedrock (in pink) and gravel (in yellow) resources (Plate 1). Thickness contours (isopachs) are shown within those sand and gravel deposits for which we have sufficient data.
3. The location of active mines, borrow pits, some depleted mines, and large proposed mines (Plate 1).
4. Brief descriptions of geologic units known to contain aggregate resources (Appendix 6).
5. A description of the geology and mining history of construction aggregates in the Yakima quadrangle (see text).

A glossary of terms used in this report can be found in Appendix 1, and a complete discussion of the methods used in this study can be found in Appendix 2.

Accuracy of Estimates

We emphasize that this report almost certainly overestimates the volume of construction aggregate within the Yakima quadrangle

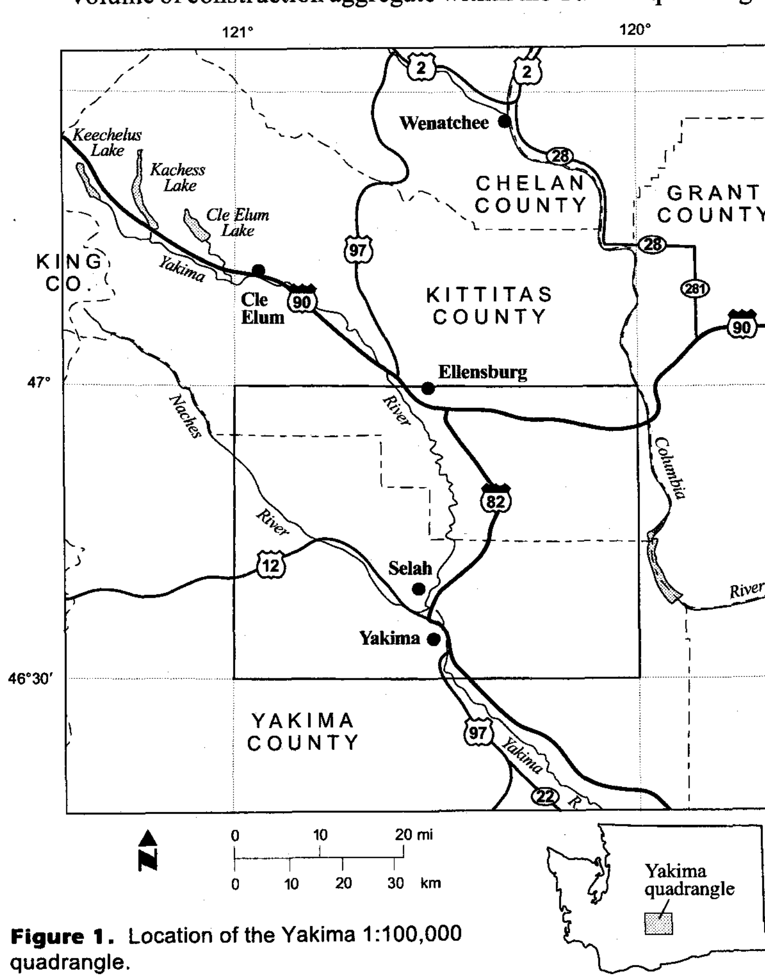

Figure 1. Location of the Yakima 1:100,000 quadrangle.

that is available under current market conditions, because of factors such as shallow bedrock under surficial gravels, diminishing rock quality with depth, unmapped areas of thick overburden, and lateral geologic variation. Furthermore, history indicates that future drilling and mining are more likely to yield disappointing results than to add significantly to hypothetical aggregate reserves. Finally, a rise in the price of construction aggregate could make some of today's subeconomic resources (such as clay-rich gravel deposits or rock buried under thick layers of overburden) commercially attractive in the future.

Table 1. Some specifications for construction aggregate products *(after Washington State Department of Transportation, 1999)*. Los Angeles Abrasion and Percent Passing U.S. No. 200 Sieve measurements are in weight percent. Los Angeles Abrasion and Degradation specifications for coarse portland cement concrete aggregate are not rigorous because the gravel is seldom exposed on the outside of concrete structures, such as foundations or sidewalks

Laboratory test	Product			
	Asphalt-treated base	Crushed (road) surfacing, top course	Coarse aggregate for portland cement concrete	Ballast (road subgrade)
Los Angeles Abrasion	≤30%	≤35%	≤35%	≤40%
Washington Degradation	≥15	≥25	not used	≥15
Sand Equivalent	≥30%	≥35%	not used	≥30%
Percent Passing U.S. No. 200 Sieve (<0.0025 in.)	2–9%	0–7.5%	0–0.5%	0–9%

Threshold of Significant Resources

Because this study is primarily designed as an aid to land-use planning, we inventoried only those resources deemed as significant to the long-term economic health of the region. Therefore, we restricted our investigation to those resources that meet the following threshold criteria:

1. The thickness of the sand and gravel or bedrock deposit appears to be in excess of 25 feet (7.5 meters).
2. The 'stripping ratio' (ratio of overburden to gravel or overburden to bedrock) is less than one to three (1:3).
3. The strength and durability of the rock meet the Washington State Department of Transportation's (WSDOT) minimum specifications for asphalt-treated base, a rock product used to construct some lower layers of asphalt roads (Table 1).
4. The area of the deposit exposed at the surface exceeds 160 acres and measures at least 1,500 feet across the minimum dimension of the deposit, or the reserves exceed 10 million cubic yards. However, a few exceptions are included where unusually thick deposits or resources of special local importance are present.

In some markets, a lack of quality gravel and bedrock has forced producers to mine lower-quality deposits. Homes and infrastructure constructed with weak gravel or bedrock generally have relatively short life cycles. We have not inventoried these lower-quality deposits because they do not meet the criteria of this study. However, Appendices 3 through 5 will serve as guides to the locations of some of the poorer-quality deposits as well as resources buried under thick overburden layers which may become more attractive under future market conditions.

Scope of Deposits Inventoried

In order to produce an objective analysis, we have inventoried all deposits meeting the threshold criteria (except those that lie within the Yakima Training Center and Yakama Indian Reservation) without consideration of environmental impacts or land-use conflicts that may be involved in permitting or extracting these resources. For example, the Yakima River flood plain has historically been a major gravel resource, and numerous mines are still operating beside the river. Future mining operations in flood plains will likely have more difficulty obtaining permits because alluvial mining can adversely impact aquatic and riparian habitat (Norman and others, 1998). Nevertheless, all Yakima River sand and gravel deposits meeting the threshold criteria are depicted in this report. Therefore, this inventory must be used with maps of environmentally sensitive areas and land-use status in order to obtain a complete picture of available aggregate within the quadrangle.

Previous Aggregate Reserve Studies

Prior to this study, the only public assessments of aggregate reserves in the Yakima 1:100,000 quadrangle were a preliminary assessment of speculative reserves by the Yakima County Planning Department (unpub. data) and a statewide reconnaissance investigation of aggregate reserves (Lingley and Manson, 1992).

GEOLOGY OF CONSTRUCTION AGGREGATES IN THE YAKIMA QUADRANGLE

The following discussion of the geology of the Yakima quadrangle emphasizes those units that are significant sources of aggregate. More detailed geologic descriptions of units being mined or considered a resource can be found in Appendix 6.

Sand and Gravel Geology

Three types of sand and gravel deposits are present in the Yakima quadrangle:

1. Recent alluvial deposits on the flood plains of rivers and larger creeks.
2. Quaternary (Pleistocene) river terrace deposits.
3. Older (Tertiary), commonly cemented alluvial and volcaniclastic deposits that are generally mapped as sedimentary rock units (Thorp Gravel and gravels of the Ellensburg Formation).

Alluvial gravel deposits along the Yakima River (unit Qa) are composed mainly of basalt clasts derived locally from the Columbia River Basalt Group and other volcanic rocks, such as andesite and dacite, from the Cascade Range to the west (Campbell, 1983). From Ellensburg to where the Yakima River cuts through Yakima Ridge (informally known as Selah Gap), the gravel deposits are dominated by basalt clasts (60–65%). South of Selah Gap, andesite and dacite clasts are found in higher percentages, most likely due to an influx of these rock types from the Naches and Tieton Rivers. Minor amounts (10–15%) of granitic, metamorphic, and sedimentary clasts are also present in the gravel deposits. Alluvial gravels meeting asphalt-treated base specifications are found along the Yakima, Naches, and Tieton Rivers as well as along Ahtanum and Wenas Creeks.

Campbell (1983) noted that two Pleistocene terraces (unit Qt) approximately 16 and 30 feet (5 and 10 meters) above the present Yakima River flood plain occur at numerous locations from Ellensburg south to Union Gap. These terraces consist of lithologies similar to those found on the modern Yakima River flood plain, although the cobbles tend to be slightly more weathered. Historically, little mining has occurred on these terraces, yet WSDOT strength and durability testing of these gravels indicates that they meet the threshold criteria of this study and should be considered significant resources (Plate 1).

The Pliocene Thorp Gravel and age-equivalent conglomerates are divided into two units: the mainstream facies and the sidestream facies (Waitt, 1979). The Thorp Gravel (unit Ᵽcg$_t$) was deposited by the ancestral Yakima River (mainstream facies) and its tributaries (sidestream facies). Only mainstream-facies deposits are likely to meet the threshold criteria of this inventory. The mainstream facies is composed of mixed lithologies, including a high percentage of hard, slightly weathered cherts, andesites, dacites, and other durable silicic rocks. The unit is more compact than overlying gravel deposits and contains a moderate amount of pore-filling clay that must be washed off the aggregate. Large volumes of sand and gravel are presently being mined from the Thorp mainstream facies in the Hutchinson pit, which lies directly north of the Yakima quadrangle approximately 2 miles northwest of the city of Ellensburg (sec. 29, T18N, R18E). Although the Hutchinson pit is located outside the Yakima quadrangle, it demonstrates that the Thorp mainstream facies can be economically mined and that these deposits meet WSDOT asphalt-treated base specifications. For these reasons, the Thorp mainstream facies gravels are shown as a significant aggregate resource (Plate 1). Although some well logs indicate that the Thorp mainstream facies may extend to depths of 200 feet in the southern Kittitas Valley, insufficient data are available to justify contouring thicknesses greater than 100 feet.

The Thorp sidestream facies crops out mainly in the southwest quarter of the map and consists mostly of basaltic gravels derived from the nearby ridges of the Yakima fold belt (Waitt, 1979; Campbell, 1983). The basalt cobbles commonly have thick weathering rinds, clayey cementation, and calcification that would require costly processing to remove. Although numerous small borrow pits are present within the deposits of the sidestream facies, they are used mainly by farmers, orchardists, and other landowners for domestic or maintenance purposes. The Thorp sidestream facies deposits rarely meet the threshold criteria of this inventory and are not considered a significant resource.

Lastly, numerous other poorly consolidated Tertiary deposits in the Yakima quadrangle contain sand and gravel (units QᵽCg, ᵽMcg$_r$, Mc$_e$, Mc$_{ev}$, and Mcg) (Walsh, 1986; Schuster, 1994). The Miocene Ellensburg Formation (unit Mc$_e$) is the most prevalent and underlies, overlies, and is interbedded with the Columbia River Basalt Group. This unit is composed mainly of volcaniclastic conglomerates, sandstones, mudstones, and lahar deposits derived from the Cascade Range and whose deposition is unrelated to the modern Yakima River drainage (Smith, 1988). Ellensburg Formation cobbles tend to be weathered and are often surrounded by large volumes of fine-grained material (clays, silts, and sands). Therefore, Ellensburg Formation deposits as a whole are not considered a significant resource, although it is possible that higher-quality deposits could be found locally.

Bedrock Geology

Bedrock in the Yakima quadrangle can be assigned to one of four geologic groups or formations. These are the Tieton Andesite, Columbia River Basalt Group, Ellensburg Formation, and Fifes Peak Formation. In our discussion below, we emphasize the Tieton Andesite and Columbia River Basalt Group, which consistently meet the threshold criteria of this study and are considered significant resources.

The Tieton Andesite (unit Qva$_{ti}$) crops out at Naches Heights, between the confluence of the Tieton and Naches Rivers and where Cowiche Canyon opens into the Naches Valley (Plate 1). This Pleistocene andesitic lava flow originated in the Cascade Range and is very hard, fresh, and durable. The unit averages 100 feet thick and may be as much as 300 feet thick in some areas. Presumably the Tieton Andesite can be mined through its entire thickness because its quality appears relatively uniform.

The series of east–west trending ridges within the Yakima quadrangle are composed chiefly of Columbia River Basalt Group flood basalts (unit Mv and its subdivisions). Numerous individual basalt flows make up the Columbia River Basalt Group and all of these contain thick zones suitable for use as crushed aggregate (Mike Hammond, WSDOT South Central Region, oral commun., 2000). Components of a typical Columbia River Basalt Group basalt flow are shown in Figure 2. The entablature and colonnade of basalt flows provide high-quality crushed aggregate, quarry stone, riprap, and decorative 'shale' rock. In these zones, the rock is usually very hard and durable, has undergone little weathering, and has many fractures and joints that developed during the cooling process or deformation. Locally, vesicular tops have been removed by erosion, and the pillow-palagonite bases occur only if the lava cooled under the waters of a Miocene lake. The cumulative basalt flow sequence exceeds several thousand feet thick, yet the deepest quarry is permitted to a depth of only 290 feet (Rest Haven riprap; sec. 7, T13N, R19E). The basalt of the Columbia River Basalt Group has been designated as a rock resource wherever it is located in the Yakima quadrangle (Walsh, 1986; Schuster, 1994; Plate 1).

The Ellensburg Formation (unit Mc$_e$) deposits were discussed in the preceding sand and gravel geology section. These deposits, which are not considered a resource, form interbeds that commonly separate individual basalt flows of the Columbia River Basalt Group. These interbeds usually range in thickness from 5 to 50 feet. When the interbed thickness exceeds 30 to 40 feet, it may be prohibitively expensive to mine the underlying basalt. In the Ryegrass area in the northeast corner of the quadrangle, the Vantage Member of the Ellensburg Formation is approximately 30 feet thick (Mackin, 1961). In the Selah Butte area near the center of the quadrangle, the Selah Member of the Ellensburg Formation is more than 100 feet thick (Schmincke, 1964).

The Fifes Peak Formation (unit Mva$_{fp}$) is the oldest rock unit in the quadrangle (23–26 million years old) and crops out in small areas on the western margin of the study area. Most of it is part of the apron facies of the Edgar Rock volcano and consists of ash-tephra, lahar deposits, and other soft, crumbly volcaniclastics (Campbell and Gusey, 1992). The Fifes Peak Formation contains a few small borrow pits used by the U.S. Forest Service for local maintenance of logging roads, but generally the rock does not meet the threshold criteria of this inventory and is not considered a resource.

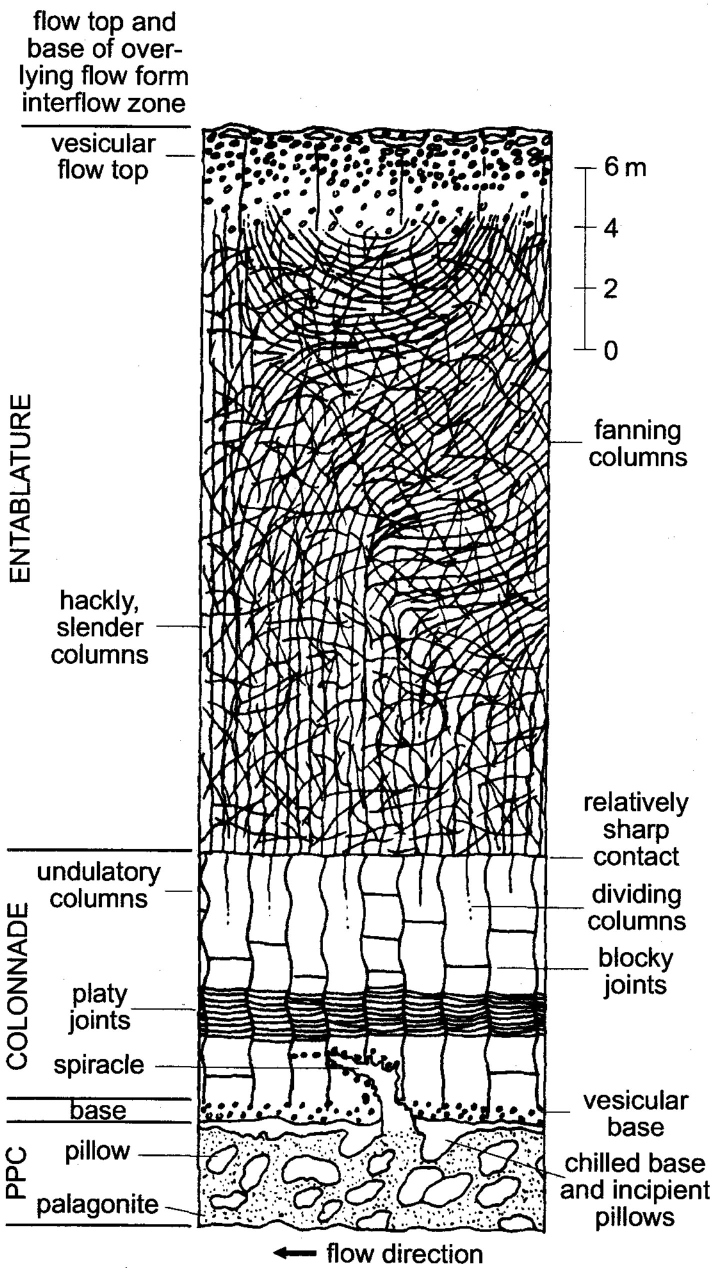

Figure 2. Cross section of a typical flow in the Columbia River Basalt Group showing, in idealized form, jointing patterns and other structures. PPC, pillow-palagonite (hyaloclastite) complex, which is present at the base of flows that entered water. *(Modified from Swanson, 1967, and Swanson and Wright, 1978.)*

AGGREGATE MINING AND SIGNIFICANT DEPOSITS

Aggregate mining has occurred at more than 240 sites within the Yakima quadrangle. There are approximately 13 permitted gravel pits and 20 permitted rock quarries currently operating in the quadrangle (Appendix 3). An additional 25 pits and 9 quarries are or have been operated by the WSDOT. Pits and quarries intermittently operated for forest road construction and repair include at least six by the U.S. Forest Service, two by the WADNR, and one by a major timber company. Tables 2 and 3 show major sand and gravel pits and bedrock quarries in the Yakima quadrangle.

Interviews with major pit and quarry operators indicate that current demand for aggregate in the Yakima Valley market is approximately 1.6 million tons per year. The southern Kittitas Valley market is considerably smaller at approximately 200,000 tons per year. Therefore, the population of the Yakima quadrangle consumes approximately 1.8 million tons of sand, gravel, and bedrock per year. Historically, much of the aggregate produced in the Yakima quadrangle originated from large flood plain gravel pits. Most of these pits are either depleted or nearing depletion, but two large gravel pits have been proposed in the Yakima quadrangle. If current trends continue, we expect the number of permitted bedrock quarries to increase as the number of permitted gravel pits decreases due to depletion of commercially viable gravel pit sites.

In the following discussion, the use of the terms 'active' and 'terminated' refers only to mines that have WADNR permit numbers. Small pits and quarries that have not been permitted are referred to as borrow pits.

Sand and Gravel Resources

Historical gravel mining combined with WSDOT test data show that alluvium along the Yakima and Naches Rivers, as well as some other alluvium in the quadrangle, is consistently of high quality (Table 4). Almost every pond located within the flood plains of the Yakima and Naches Rivers is the result of gravel mining. The average gravel pit in the Yakima quadrangle is permitted to a depth of 33 feet, covers 44 acres, and has 2 feet of overburden (Appendix 3).

Along the Yakima and Naches Rivers and Ahtanum Creek, there are a number of areas where mining has occurred and (or) gravel thicknesses are greater than 25 feet (Plate 1). Along the Yakima River, these include the southern Kittitas, Selah, and Yakima Valleys. Deposits along the Naches River have been divided into two separate areas: one surrounding the town of Nile and the second from the town of Naches downstream to Cowiche Canyon. The only potentially thick gravel deposit along Ahtanum Creek is near the town of Tampico. The above areas are discussed in more detail below.

YAKIMA RIVER

The Yakima River alluvium, lower terrace gravels, and Thorp Gravel mainstream facies deposits are all mined in southern Kittitas Valley (sec. 13, T17N, R18E). The thickest gravel we could justify contouring in this valley is 100 feet, with a maximum thickness of 205 feet identified in a water well. The uppermost 25 feet is generally alluvium that overlies Thorp Gravel mainstream facies deposits. Within the valley there are two active mines (WADNR permit nos. 10051 and 10150), two terminated mines (WADNR permit nos. 10163 and 11705), and 19 borrow pits, covering a total of more than 122 acres.

The Yakima River alluvium and lower terrace deposits in Selah Valley (sec. 31, T14N, R19E) have been intensely mined. The thickest gravel we contoured in the area is 25 feet, with a maximum thickness of 46 feet identified in a water well. Within this valley there are one active mine (WADNR permit no. 10175), three terminated mines (WADNR permit nos. 10719, 10750, and 10769), one large proposed mine (WADNR permit application no. 12846), and seven borrow pits, covering a total of more than 570 acres. The largest active mine in the quadrangle is the Selah pit operated by Central Pre-Mix, which is being mined to the underlying Ellensburg Formation. Although this pit is the largest aggregate producer in the Yakima quadrangle, it is almost depleted.

The Yakima River alluvium and lower terrace deposits in Yakima Valley (sec. 28, T12N, R19E) have been extensively mined. The thickest gravel we contoured in this valley is 100 feet, with a maximum thickness of 102 feet identified in a water well. Within this valley there are eight active mines (WADNR permit nos. 10045, 10198, 10317, 10351, 10794, 11434, 11151, and 11513), two terminated mines (WADNR permit nos. 10747 and 11519), one proposed large mine, and 23 borrow pits, covering a total of more than 533 acres.

Table 2. Some larger gravel pits in the Yakima quadrangle. Values in parentheses represent predicted future annual production rate for proposed mines

Mine name	Current operator	Location	Approximate reserves (million tons)	Approximate annual production rate (million tons)
Selah pit	Central Pre-Mix	1.5 miles east of Selah	1	0.6
Newland pit	Central Pre-Mix	3 miles southeast of Yakima	0.5	0.25
East Valley mine *(proposed)*	Central Pre-Mix	3.5 miles southeast of Yakima	12	0 (0.9)
Monson pit *(proposed)*	Central Pre-Mix	1 mile east of Selah	7	0 (0.5)

NACHES RIVER

Deposits along the Naches River near Nile (sec. 3, T15N, R15E) are relatively thin and narrow. Only five small borrow pits are present. The thickest gravel we contoured in the area is 25 feet, with a maximum thickness of 49 feet identified in a water well.

Deposits along the Naches River near Naches (sec. 10, T14N, R17E) tend to increase in thickness downstream. In the Upper Naches Valley, the thickest gravel we contoured is 50 feet, with a maximum thickness of 70 feet identified in a water well. In the Lower Naches Valley, the thickest gravel we contoured is 75 feet, with a maximum thickness of 94 feet identified in a water well. Two terminated mines (WADNR permit nos. 10692 and 10878) together occupy 12 acres in the Upper Naches Valley. Two mines located adjacent to one another, one active (WADNR permit no. 10633) and one terminated (WADNR permit no. 11455), together occupy 55 acres in the Lower Naches Valley. In addition, there are a total of eight small borrow pits in the Upper and Lower Naches Valleys.

AHTANUM CREEK

A small polygon of sand and gravel is shown along Ahtanum Creek near Tampico (sec 17, T12N, R16E) (Plate 1). Strength and durability testing from one pit in this unit indicates high-quality gravel. Well logs suggest that there may be up to 50 feet of clean gravel within the polygon, although distinguishing between alluvium and Thorp Gravel sidestream facies in the well logs is difficult. Basaltic bedrock usually underlies this gravel deposit. Two small borrow pits are located within this polygon.

OTHER AREAS

Recently, interest has increased in upland gravel sites. No strength and durability tests are available for these gravels, so it is unknown if they meet the threshold criteria of this study. There is an active gravel pit in Stone Quarry Canyon (sec. 27, T17N, R18E) and a proposed mine at the southern end of Birchfield Road (sec. 10, T12N, R19E). The proposed Birchfield pit's main purpose is for extraction of blending sand from the Ellensburg Formation. Gravel in an adjacent conglomerate layer has little iron staining or calcite cement, but appears to consist of approximately 50 percent weathered andesitic clasts, supporting our decision to not include the Ellensburg Formation as a gravel resource.

A thin layer of alluvial gravel has been deposited by creeks flowing through Ahtanum Valley (sec. 11, T12N, R17E). Well logs commonly show about 5 feet of overburden overlying about 15 feet of clean gravel. This gravel is likely of high quality, although no testing has been done in the lower valley. A layer described as a clay-rich or cemented gravel usually lies below the alluvial gravel. This layer is likely the sidestream facies of the Thorp Gravel, which crops out on both sides of the valley. The deposits in this valley are not considered significant resources because they are thin, strength and durability tests are unavailable, and the underlying sidestream facies of the Thorp Gravel rarely meets the threshold criteria of this inventory.

West of Ellensburg, Manastash Creek fans out into southern Kittitas Valley (sec. 12, T17N, R17E). Overburden is generally less than 5 feet thick, overlying a clean gravel layer that commonly contains cobbles and boulders of basalt that are sometimes angular. This gravel layer can be up to 40 feet thick. The clean gravel is underlain by clay-rich or cemented gravel of the sidestream facies of the Thorp Gravel, like in the lower Ahta-

Table 3. Some larger quarries in the Yakima quadrangle. Values in parentheses represent predicted future annual production rate for proposed mines

Mine name	Current operator	Location	Approximate reserves (million tons)	Approximate annual production rate (million tons)
Rowley pit	Superior Asphalt and Concrete	1.5 miles southeast of Selah	7	0 (0.3)
Anderson quarry[1]	Columbia Ready-Mix	6 miles southeast of Yakima	5	0.2
Horseshoe Bend	Ken Williamson	6.5 miles northwest of Naches	2.7	?
Ahtanum quarry	Herke Rock	13 miles southwest of Yakima	~20	0.18
Rest Haven riprap	Columbia Ready-Mix	3 miles southeast of Selah	2	0.07
Thayer riprap	Ellensburg Cement Products	5 miles south of Ellensburg	*withheld*	*withheld*
Summitview quarry	Yakima County Public Works Dept.	6.5 miles southwest of Selah	2	0.12
Summitview quarry	Ron Anderson	7.5 miles southwest of Selah	6	0.04

[1] An expansion of the Anderson quarry to 70 acres with reserves of more than 20 million tons has been proposed.

Table 4. Aggregate quality data. Asphalt-treated base specifications: Los Angeles (LA) Abrasion ≤30%; Degradation ≥15; Sand Equivalent ≥30%. n/a, not applicable

		Area or geologic unit	No. of mines (permitted)	Rock type	LA Abrasion		Degradation		Sand Equivalent		Stabilometer R Value	
					Range	Mean (n)	Range	Mean (n)	Range	Mean (n)	Range	Mean (n)
SAND AND GRAVEL	Alluvium	Naches River near Nile	6 (0)	gravel	12–21	15.7 (3)	59–76	67.5 (2)	44–73	57.7 (3)	none	none
SAND AND GRAVEL	Alluvium	Naches Valley	14 (4)	gravel	16–20	17.8 (4)	73–75	74.3 (3)	36–81	64.8 (4)	57–80	72.2 (6)
SAND AND GRAVEL	Alluvium	southern Kittitas Valley	24 (4)	gravel	11-18	13.9 (16)	61–78	68.5 (12)	21–92	62.6 (15)	69–80	76.2 (7)
SAND AND GRAVEL	Alluvium	Selah Valley	11 (4)	gravel	13–19	15.8 (5)	68–74	71.8 (4)	73–79	76 (2)	74–79	76.3 (4)
SAND AND GRAVEL	Alluvium	Yakima Valley	24 (9)	gravel	12–28	17.1 (9)	45–79	72 (9)	8–83	56.5 (6)	72–76	74.5 (6)
SAND AND GRAVEL	Alluvium	Ahtanum Creek near Tampico	2 (0)	gravel	20	20 (1)	79	79 (1)	60	60 (1)	none	none
SAND AND GRAVEL	Alluvium	Wenas Valley	1 (1)	gravel	18	18 (1)	79	79 (1)	none	none	none	none
SAND AND GRAVEL	Alluvium	all alluvium	116 (26)	gravel	10.9–28	15.3 (55)	45–84	72.8 (48)	8–92	63.3 (49)	57–80	73.9 (34)
SAND AND GRAVEL	Thorp Gravel	PLcg$_t$	5 (1)	gravel	21	21 (1)	45	45 (1)	none	none	none	none
BEDROCK	Tieton Andesite	Qva$_{ti}$	5 (2)	andesite	none	none	65	65 (1)	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_{gN2}$	26 (6)	basalt	10–27	17.7 (7)	53–88	71.6 (7)	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_{gR2}$	5 (2)	basalt	13–21	16.8 (4)	83–88	85.8 (4)	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_s$	3 (2)	basalt	16–22	18.7 (3)	19–65	41.7 (3)	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_{se}$	2 (2)	basalt	none	none	none	none	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_{sp}$	5 (3)	basalt	15–18	16.5 (2)	36-80	58 (2)	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_w$	8 (2)	basalt	15–17	16 (2)	48–77	63.7 (3)	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_{wfs}$	24 (8)	basalt	12–31	20.4 (11)	44–82	65.3 (10)	21–34	27.5 (2)	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_{wpr}$	1 (0)	basalt	none	none	none	none	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	Mv$_{wr}$	1 (0)	basalt	none	none	none	none	none	none	n/a	n/a
BEDROCK	Columbia River Basalt Group (CRBG)	all CRBG	77 (25)	basalt	10–31	18.5 (29)	19–88	66.5 (29)	21–34	27.5 (2)	n/a	n/a

num Valley. Within this area there are one terminated mine (WADNR permit no. 11034) and two borrow pits, together covering more than 10 acres. This deposit is not depicted as a significant resource at this time due to the lack of strength and durability testing.

Wenas Creek has deposited alluvium within its valley (sec. 30, T15N, R18E). Strength and durability testing from one gravel pit indicates high-quality material. Well logs show that overburden thickness is usually about 5 feet, and there may be 20 feet of clean to dirty gravel overlying sandstone of the Ellensburg Formation. This deposit is not considered a significant resource because it does not meet our minimum thickness criterion.

Bedrock Resources

Bedrock quarrying in the Yakima quadrangle mostly occurs near the towns of Yakima, Selah, and Ellensburg and adjacent to Interstates 82 and 90 (Fig. 1; Plate 1). The average commercial bedrock quarry in the Yakima quadrangle is permitted to a depth of 83 feet, covers 23 acres, and has one foot of overburden (Appendix 3). The two rock groups that contain large volumes of quality bedrock are the Tieton Andesite and the Columbia River Basalt Group.

TIETON ANDESITE

The Tieton Andesite, forming Naches Heights (sec. 35, T14N, R17E), has been quarried on a limited scale. A number of historic buildings in Yakima were constructed using this rock. Within the Tieton Andesite there are only two terminated mines (WADNR permit nos. 10757 and 10724), and three borrow pits, covering a total of more than 8 acres.

COLUMBIA RIVER BASALT GROUP

The Columbia River Basalt Group is composed of about 140 separate flows. Analyses show that all flows tested contain high-quality rock (Table 4). The entablature (Fig. 2) generally contains the best rock for making crushed aggregate because columns within the entablature are commonly less than 1 foot in diameter and fractured. Two problems have been encountered when mining the colonnade (Fig. 2) to produce crushed aggregate. First, some of the columns are too large (>2 feet) to fit in a typical crusher. Second, columns with platy joints (often referred to as 'shale') can be excessively weathered where joints are closely spaced. Rock from vesicular tops and pillow-palagonite bases is generally discarded in quarry operations due to weathering and large clay contents. The vesicular tops are locally eroded away and pillow-palagonite bases occur only if the lava cooled underwater. Fortunately, the vesicular tops and pillow-palagonite bases constitute less than 20 percent of each flow. Within the Columbia River Basalt Group, there are 21 active mines (WADNR permit nos. 10048, 10052, 10444, 10728, 10881, 11289, 11600, 11686, 11971, 12000, 12334, 12365, 12774, 12785, 12796, 12801, 12818, 12858, 12905, 12908, and 12938), four terminated mines (WADNR permit nos. 10750, 11025, 11064 and 11503), and 50 borrow pits, covering a total of more than 525 acres.

VOLUME OF AGGREGATE

The volume of aggregate currently available in major permitted mines was tabulated using data supplied by mine operators in November 2000 (Tables 2 and 3). Reserves for permitted properties are based on values listed on permit applications filed with the WADNR (Form SM-2) and augmented with information from field investigations and personal communication with operators. Reserves in tons are obtained by multiplying cubic yards by conversion factors of 1.6 tons per cubic yard for sand and gravel, 2.4 tons per cubic yard for basalt, and 2.2 tons per cubic yard for andesite.

Depletion is estimated either by field observation or by multiplying the average annual production rate by the number of years of past production. In many cases the operator confirmed the percent depletion.

Currently permitted gravel pits in the Yakima quadrangle contain about 2 million tons (1.25 million cubic yards) of aggregate in reserve. The production rate for these pits is about 0.85 million tons per year (0.5 million cubic yards per year). Based on these figures, these pits will be depleted at the earliest in just over 2 years. Currently permitted bedrock quarries have about 46 million tons (19 million cubic yards) of aggregate in reserve. The production rate for these quarries is 1 million tons (0.4 million cubic yards) per year. Based on these figures, these bedrock quarries will be depleted in about 45 years. While the depletion calculation for gravel and bedrock mines is informative, it is merely a snapshot in time. A number of factors can cause these calculations to be misleading, including changing market conditions, inaccuracies in reserve estimates, and the shifting of production to new mines. Also, as quarries increase production to adjust for the depletion of gravel pits, they will be depleted faster than our calculation suggests.

SUMMARY

The Yakima 1:100,000 quadrangle contains a moderate volume of high-quality gravel and abundant high-quality bedrock (Table 4; Plate 1). In recent years, the number of permits issued for quarries in the area has increased as the number of permits issued for gravel pits has decreased. The most significant gravel deposits are alluvium, lower terrace deposits, and Thorp mainstream facies gravels found along the Yakima and Naches Rivers. The most significant bedrock units are the Tieton Andesite and Columbia River Basalt Group.

Pits within the flood plains of the Yakima and Naches Rivers are the major producers of sand and gravel. Crushed aggregate and sand and gravel produced from these pits have high strength and durability. The largest mine properties in terms of acreage are the depleted Beech Street and Edler pits and the nearly depleted Selah and Newland pits. Two new gravel pits are proposed within the flood plain of the Yakima River, and one new pit for extraction of blending sand is proposed in the Ellensburg Formation on the north side of the Rattlesnake Hills.

The Yakima quadrangle has abundant bedrock that makes excellent crushed aggregate (Plate 1; Table 4). While the Tieton Andesite has not been used extensively for quarried bedrock, field inspections and WSDOT test data suggest that the rock is very strong. Basalt flow outcrops of the Columbia River Basalt Group cover approximately half of the map area, and each flow contains high-quality bedrock. All currently permitted large quarries are located within the Columbia River Basalt Group.

The costly haul on Interstate 82 over Umtanum Ridge separates the Kittitas Valley and Yakima Valley markets. The Yakima Valley market consumes approximately 1.6 million tons of aggregate each year while the southern Kittitas Valley market consumes approximately 200,000 tons per year, bringing the total demand in the Yakima 1:100,000 quadrangle to about 1.8 million tons per year. Currently permitted gravel pits contain about 2 million tons (1.25 million cubic yards) of aggregate in reserve and produce about 0.85 million tons per year (0.5 million cubic yards per year). Currently permitted bedrock quarries have about 46 million tons (19 million cubic yards) of resource in reserve and produce about 1 million tons (0.4 million cubic yards) per year.

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REFERENCES CITED

American Geological Institute, compiler, 1997, Dictionary of mining, mineral, and related terms; 2nd ed.: American Geological Institute, 646 p.

Bentley, R. D.; Anderson, J. L.; Campbell, N. P.; Swanson, D. A., 1980, Stratigraphy and structure of the Yakima Indian Reservation, with emphasis on the Columbia River Basalt Group: U.S. Geological Survey Open-File Report 80-200, 85 p., 1 plate.

Bentley, R. D.; Campbell, N. P., 1983a, Geologic map of the Ellensburg quadrangle, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-28, 1 sheet, scale 1:62,500.

Bentley, R. D.; Campbell, N. P., 1983b, Geologic map of the Yakima quadrangle, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-29, 1 sheet, scale 1:62,500.

Bentley, R. D.; Campbell, N. P.; Powell, J. E., 1993, Geologic maps of part of the Yakima fold belt, northeastern Yakima County, Washington: Washington Division of Geology and Earth Resources Open File Report 93-3, 13 p., 5 plates.

Campbell, N. P., 1976, Preliminary geologic map of the Yakima area: Washington Division of Geology and Earth Resources Open File Report 76-11, 1 sheet, scale 1:24,000.

Campbell, N. P., 1983, Correlation of late Cenozoic gravel deposits along the Yakima River drainage from Ellensburg to Richland, Washington: Northwest Science, v. 57, no. 3, p. 179-193.

Campbell, N. P.; Gusey, D. L., 1992, Geology of the Naches Ranger District, Wenatchee National Forest, Kittitas and Yakima Counties, Washington: Washington Division of Geology and Earth Resources Open File Report 92-3, 12 p., 2 plates.

Jackson, J. A., editor, 1997, Glossary of geology; 4th ed.: American Geological Institute, 769 p.

Kroft, D. J., 1972, Sand and gravel deposits in western King County, Washington: University of Washington Master of Science thesis, 62 p.

Lingley, W. S., Jr.; Jazdzewski, S. P., 1994, Aspects of growth management planning for mineral resource lands: Washington Geology, v. 22, no. 2, p. 36-45.

Lingley, W. S., Jr.; Manson, C. J., 1992, Directory of Washington mining operations, 1992: Washington Division of Geology and Earth Resources Information Circular 87, 76 p.

Loen, J. S.; Lingley, W. S., Jr.; Anderson, Garth; Lapen, T. J., 2001, Reconnaissance investigation of sand, gravel, and quarried bedrock resources in the Bellingham 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources Information Circular 91, 45 p., 1 plate.

Mackin, J. H., 1961, A stratigraphic section in the Yakima Basalt and the Ellensburg Formation in south-central Washington: Washington Division of Mines and Geology Report of Investigations 19, 45 p.

Norman, D. K.; Cederholm, C. J.; Lingley, W. S., Jr., 1998, Flood plains, salmon habitat, and sand and gravel mining: Washington Geology, v. 26, no. 2/3, p. 3-20.

Norman, D. K.; Lingley, W. S., Jr., 1992, Reclamation of sand and gravel mines: Washington Geology, v. 20, no. 3, p. 20-31.

Schmincke, H.-U., 1964, Petrology, paleocurrents, and stratigraphy of the Ellensburg Formation and interbedded Yakima Basalt flows, south-central Washington: Johns Hopkins University Doctor of Philosophy thesis, 426 p.

Schuster, J. E., compiler, 1994, Geologic map of the east half of the Yakima 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 94-12, 19 p., 1 plate.

Schuster, J. E.; Gulick, C. W.; Reidel, S. P.; Fecht, K. R.; Zurenko, Stephanie, 1997, Geologic map of Washington—Southeast quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-45, 2 sheets, scale 1:250,000, with 20 p. text.

Smith, G. A., 1988, Neogene synvolcanic and syntectonic sedimentation in central Washington: Geological Society of America Bulletin, v. 100, no. 9, p. 1479-1492.

Swanson, D. A., 1967, Yakima Basalt of the Tieton River area, south-central Washington: Geological Society of America Bulletin, v. 78, no. 9, p. 1077-1109.

Swanson, D. A.; Wright, T. L., 1978, Bedrock geology of the northern Columbia Plateau and adjacent areas. *In* Baker, V. R.; Nummedal, Dag, editors, The channeled scablands—A guide to the geomorphology of the Columbia Basin, Washington: U.S. National Aeronautics and Space Administration, p. 37-57.

U.S. Geological Survey, 1976, Principles of the mineral resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey: U.S. Geological Survey Bulletin 1450-A, 5 p.

Waitt, R. B., Jr., 1979, Late Cenozoic deposits, landforms, stratigraphy, and tectonism in Kittitas Valley, Washington: U.S. Geological Survey Professional Paper 1127, 18 p.

Walsh, T. J., compiler, 1986, Geologic map of the west half of the Yakima quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 86-4, 1 sheet, scale 1:100,000, with 9 p. text.

Washington Office of Financial Management, 2000, 1999 data book: Washington Office of Financial Management *available at* http://www.ofm.wa.gov/databook/

Washington State Department of Transportation, 1999, Standard specifications for road, bridge, and municipal construction, 2000—English units: Washington State Department of Transportation, 1 v. ■

Appendix 1. Glossary of mining-related terms

The terms defined below are modified from Jackson (1997), American Geological Institute (1997), and Washington State Department of Transportation (1999).

Aggregate, construction aggregate – A mixture of sand and gravel or sand and crushed rock used in portland cement concrete, asphaltic concrete, mortar, plaster, or graded fill. Gravel and crushed stone that are in grain-to-grain contact in the aggregate are strong enough to support the weight of roads, buildings, or other infrastructure. The sand keeps the coarse aggregate in grain-to-grain contact by limiting the ability of the larger particles to shift laterally.

Alluvium – Unconsolidated boulders, cobbles, pebbles, sand, silt, and (or) clay deposited relatively recently from a stream or river and sorted by the current velocity.

Andesite – A dark colored, extrusive volcanic rock. When it is porphyritic it contains phenocrysts of plagioclase and one or more mafic minerals, commonly biotite, hornblende, or pyroxene. The fine-grained groundmass consists of mineralogy similar to the phenocrysts with the inclusion of quartz. This rock is usually deposited as lava flows or shallowly intruded sills.

Asphalt – Heavy oil (tar) produced from oil wells that is used to make asphalt roads.

Asphaltic concrete – Concrete made of asphalt and crushed aggregate.

Asphalt-treated base – A specific construction aggregate used to prepare the base of an asphaltic concrete road.

Basalt – A black volcanic bedrock that is finely crystalline. Basalt is the most common rock in the earth's crust and forms the floor of almost all of the oceans. In Washington, basalt covers the entire Columbia Basin and much of the Cascade Range and high Olympic Mountains. Basalt that erupted on land (for example, the Columbia River Basalt Group) is hard and makes excellent crushed aggregate, whereas basalt that erupted on the sea floor is commonly weak (for example, much of the Crescent Formation basalts).

Batching, batch plant – A concrete manufacturing process or plant that mixes aggregate and portland cement or aggregate and asphaltic cement to manufacture concrete. Basically, a batch plant functions like a gigantic eggbeater and bowl.

Blend(ing) sand – Sand that is combined with coarse aggregate in order to achieve the appropriate grading for an end product. The sand must be clean and hard with a sand equivalent of at least 27.

Boulder – A rock fragment larger than 10 inches (256 millimeters) that has been somewhat rounded by abrasion in the course of transport.

Cement – (1) baked limestone dust and water that glues aggregate particles together to form concrete; (2) minerals, usually precipitated from hydrothermal fluids, that naturally glue the grains of a rock together creating a hard sediment or harder rock.

Clast – A rock fragment of any size, initially broken off bedrock by the force of water freezing in cracks or by impact from another rock. Clasts become smaller as they roll off a hillside and (or) down a stream.

Clay – Sediment composed of particles that are plastic, consolidated when dry, and are smaller than 0.000079 inch (0.002 millimeter). Clay will not support weight (it behaves as a paste) because it is composed primarily of platy clay minerals. Clay is unsuitable for use in construction aggregates, and even small amounts must be washed off coarser aggregate.

Coarse aggregate – Gravel or crushed stone that is larger than ¼ inch (4.76 millimeters). All clasts in coarse aggregate are larger than pea gravel (pebbles, cobbles, and boulders).

Cobble – A rock fragment larger than a pebble, but smaller than a boulder, having a diameter in the range of 2.5 to 10 inches (64–256 millimeters) that has been somewhat rounded by abrasion in the course of transport.

Construction aggregate – *see Aggregate*

Cross-bed – A bed inclined at an angle to the main plane of stratification. Usually indicates deposition in a delta.

Crushed stone – Bedrock, cobbles, or boulders that have been crushed with a mechanical crusher to gravel-size rock fragments with at least three freshly broken faces. Crushed stone makes an excellent base course for road construction because the rock fragments tend to form an interlocking matrix. It is the only material suitable for asphaltic concrete because asphalt only sticks to freshly broken surfaces.

Degradation Test – A laboratory test designed to test the durability of rock under wet conditions. The degradation number indicates the percentage of rock remaining intact after tumbling with steel balls in a wet chamber. Large numbers indicate favorable rock.

Fine aggregate – Sand and gravel or crushed stone that will pass through a ¼-inch sieve (4.76 millimeters), but will be trapped in a 200 mesh (ultrafine) sieve.

Granite – A light gray or pink, coarsely crystalline (typically 1/8-inch crystals) intrusive igneous rock composed of the hard minerals quartz and feldspar with minor amounts of black mica and black iron-magnesium-rich minerals. Granite and closely related rocks can make excellent construction aggregate.

Gravel – An unconsolidated natural accumulation of typically rounded rock fragments resulting from erosion and consisting predominantly of particles larger than sand, such as boulders, cobbles, and pebbles, in any combination.

Intrusive rock – Igneous rock that was emplaced below the earth's surface as a magma that cooled very slowly to form a coarsely crystalline rock.

Kame – A hummock, terrace, or short ridge composed of stratified sand and gravel deposited at the margin of a glacier as a delta or fan. In Washington, the term is generally applied to landforms created by deposition in the low area between the margin of a glacial ice sheet and the confining hills. After the ice has melted away, a high-quality sand and gravel deposit frequently remains.

Limestone – A rock composed of the mineral calcite. Normally, these are rocks deposited in the ocean from materials that are by-products or remnants of shells. Limestone is an important source of construction aggregate in much of the nation.

Los Angeles Abrasion Test – A laboratory test to assess the strength of aggregate under dry conditions. A 100-pound sample is placed in a tumbler resembling a washing machine with a tungsten carbide ball weighing about five pounds. The tumbler is revolved 500 times and then the sample is passed through a U.S. Standard No. 4 sieve. The larger the percent of the sample that passes through the sieve, the weaker the sample. The Los Angeles Abrasion number indicates the percent of the sample that has passed through the sieve.

Outwash – Sand, gravel, and coarser round rock deposited from streams and rivers issuing from alpine or continental (ice-age) glaciers. Proximal outwash was deposited relatively close to the snout of a glacier and is poorly sorted and has a large fraction of cobbles and boulders. Distal outwash was deposited miles from the edge of the glacier and is relatively well sorted and dominated by sand.

Overburden – The material that overlies an aggregate or mineral resource and must be removed before mining the underlying material.

Pebble – A stone, usually rounded by water transport, 1/6 to 2.5 inches (4–64 millimeters) in diameter—the size of a small pea to that of a tennis ball.

Pebble imbrication – A sedimentary fabric characterized by disk-shaped or elongate pebbles dipping in a preferred direction at an angle to the bedding. It is commonly displayed by pebbles on a stream bed, where flowing water tips the pebbles so that their flat surfaces dip upstream.

Pit – This term is restricted herein to sand and gravel mines, regardless of size. A borrow pit is a small (<3 acre) mine that periodically produces unprocessed gravel and other sediment, generally for use as fill.

Pit run – Unprocessed material taken directly from the undisturbed geologic formation.

Portland cement – Cement made by heating limestone to about 2,700°F (calcining) to form lime. This lime is mixed with small amounts of water and dries to a hard adhesive that can glue aggregate together to form portland cement concrete. Portland cement by itself does not have great compressive strength, and it is costly because of the heat used in its manufacture. For these reasons, aggregate is added to form concrete. The gravel in portland cement concrete has great compressive strength and adds inexpensive filler to the mix.

Quarry – Used exclusively herein for mines that produce aggregate by blasting bedrock.

Round rock, round rock aggregate – Coarse aggregate that has been rounded by the process of stream or glacial transport. It generally has greater value than crushed aggregate because it is less expensive to mine, easy to mix in batch plants, and easy to finish to a smooth surface with trowels or other tools when used in concrete. Asphalt does not adhere effectively to round rock aggregate.

Sand Equivalent Test – A laboratory test that measures the cleanness of a sample in terms of the relative proportion of fine-grained dust or clay. High numbers indicate less dust and (or) clay, whereas low numbers indicate greater plasticity. Favorable samples have values greater than 30.

Silt – Sediment composed of particles that are unconsolidated or poorly consolidated when dry and will pass a U.S. Standard No. 200 sieve (0.0025 inch or 0.074 millimeter) but are larger than clay (0.000079 inch or 0.002 millimeter). Silt has little or no cohesive strength because it contains a small proportion of clay minerals. Abundant silt can render a gravel deposit unsuitable for use in construction aggregates.

Specific gravity – The specific gravity of a sample is the weight of the substance relative to the weight of an equal volume of water. The specific gravities of water, weak aggregate, granite, limestone, and basalt are 1.0, 1.95, 2.65, 2.72, and 3.2 grams per cubic centimeter, respectively.

Stabilometer R Value Test – A laboratory test that measures horizontal deformation when a vertical weight is applied. High numbers indicate stronger materials. Favorable samples have values greater than 70.

Till – Very poorly sorted clay, silt, sand, gravel, cobbles, and boulders deposited directly from glacial ice in the form of a moraine or a compact blanket of sediment under the ice. Generally, till is unsuitable for construction aggregate.

Appendix 2. Methods

INVENTORY PHILOSOPHY

Two end-member philosophies for resource inventory have been employed in Washington: (1) strictly factual reporting showing only those sand, gravel, and bedrock resources that have been proven to exist because they are part of active mines, and (2) a speculative approach that reports all of the potential aggregate deposits that might exist, as determined from surficial geologic or soils mapping. Both approaches have shortcomings. The first philosophy results in underestimation of available aggregate in any given area by ignoring high-quality deposits that have not been mined. The second philosophy results in overestimation of the resource because this method cannot adequately account for the heterogeneous nature of aggregate-bearing geologic units. In this study, we attempt to achieve a balance between these two philosophies using a method developed by William S. Lingley, Jr. (Loen and others, 2001) that includes the geologic and engineering criteria described below.

The accuracy of any assessment of undiscovered gravel or bedrock resources, whether performed as a proprietary exploration project or as a governmental or academic research study, is largely controlled by the quantity and quality of available subsurface data. As a general rule, subsurface information is not readily available for undeveloped deposits. Consequently, mineral economists categorize resources based on degree of certainty that any given deposit actually exists, mainly as determined from subsurface and other data.

The most commonly used categories are identified and undiscovered reserves, which are further subdivided as shown on Table 5. In order to demonstrate that an identified (or commercially viable) resource exists, the geology of the deposit must be very well known and (or) the deposit must have been defined by closely spaced exploratory drilling. Such costly work is beyond the scope of this study. Conversely, studies that rely solely on surficial information in order to delineate speculative undiscovered reserves are of little value to industry and have led to poor land-use decisions.

In this study, we mapped hypothetical (and some speculative) undiscovered reserves throughout the state as defined in Table 5 and shown on Plate 1. The most widely available source of subsurface geological data for mapping hypothetical reserves is water-well logs, but the accuracy of information on these logs is generally very poor or even misleading. To reduce the inherent uncertainty introduced by use of these logs, we depict hypothetical reserves only where the average of data from several water wells, together with other information such as landform analysis (geomorphology), geotechnical bores, outcrop descriptions, hydrologic data, and mine data allow reasonable extrapolation of surficial data into the subsurface. These hypothetical reserves are shown on Plate 1 with isopachs (thickness contours) for the gravel deposits. Elsewhere, speculative undiscovered reserves are mapped, but only where several data sets strongly suggest the presence of a deposit meeting the threshold criteria. These speculative reserves are shown on Plate 1 as simple polygons showing the extent of high-quality sand, gravel, or bedrock at the surface.

DEFINITION OF SIGNIFICANT RESOURCES

This study is limited to assessing significant aggregate resources. Significant aggregate resources are defined herein as those hard and durable sand and gravel or bedrock deposits that are likely to yield at least 10 million cubic yards of recoverable aggregate. Ten million cubic yards is the approximate volume necessary to maintain existing infrastructure in a 100,000-person market during the 20-year period mandated by the Growth Management Act, calculated as follows. Lingley and Manson (1992) estimated that the total annual per capita demand for sand, gravel, and crushed rock products in Washington is approximately 12 cubic yards. An informal rule of thumb used in industry and government is that about half of the demand for construction aggregates in any market will be used to repave roads, rebuild bridges, and remodel existing buildings, and half is used for new construction. Therefore, a hypothetical maintenance level of production for a 100,000-person market can be approximated as follows:

100,000 persons x *12 cubic yards/year* x *20 years* x *50%*
= *~10 million cubic yards*

Keep in mind that local governments are required to designate at least double this volume for every 100,000 people in order to comply with the Growth Management Act in accounting for new construction as well as maintenance (Lingley and Jazdzewki, 1994).

THRESHOLD CRITERIA USED IN PREPARING THIS INVENTORY

Inherent weaknesses in many common lithologies in the earth's crust, such as claystone or layered sedimentary and metamorphic rocks, coupled with unfavorable alteration and weathering processes render much of the outcropping bedrock and gravel unsuitable for construction aggregates. Furthermore, extraction or development costs may exceed expected return under current market conditions. In order to reduce the probability of including weak or insignificant resources, we have developed the fol-

Table 5. Classification of gravel and bedrock resources *(modified from U.S. Geological Survey, 1976)*

IDENTIFIED RESERVES			UNDISCOVERED RESERVES	
Measured	**Indicated**	**Inferred**	**Hypothetical**	**Speculative**
Deposit whose engineering properties, reserves in tons or cubic yards, and grain sizes are measured with a margin of error <20% (that is, a mine or a well-drilled prospect)	Deposit whose measurements, together with reasonable geologic projections, can be used to compute reserves in tons or cubic yards	Reasonable extension of indicated or measured deposit (generally <0.50 miles); thickness contours can be drawn with confidence	Undiscovered resources that may reasonably be expected to exist; applicable where landforms, water wells, proximal mines, or geophysical data justify such extension	Unexplored surficial deposit with no subsurface data
Active mine	Densely drilled deposit	Deposit with good subsurface control	Possible deposit defined only by poor subsurface control	Possible deposit; surficial data only

lowing threshold criteria to determine which resources should be included in our inventory.

THICKNESS—Only those deposits that are known or likely to exceed 25 feet (~7.5 meters) in the thickest portions are depicted. Thin gravel deposits rarely contain significant reserves. For example, a 20-foot-thick deposit covering 20 acres would yield only about 500,000 cubic yards of sand and gravel, and the value of the gravel might not exceed proceeds from selling the land in its undisturbed state for its real estate value. Moreover, current mining technology does not allow efficient excavation of thin veneers of sediment or bedrock. Thin deposits must spread over a large area in order to contain a significant volume of gravel, but relatively inexpensive excavating equipment (that is, front-end wheel loaders) cannot be used to carry pit run long distances within the mine. Finally, thinner deposits require greater surface disturbance per unit of aggregate produced, and damage to the plant/soil ecosystem increases in proportion to the surface area of mining. Therefore, permitting costs per unit of resource generally increase as a function of decreasing thickness.

SURFACE AREA AND DIMENSIONS OF THE DEPOSIT—Gravel deposits are seldom more than 100 feet thick and, consequently, the deposit must cover a large area to contain significant volumes of construction aggregate. The smallest geologic polygons inventoried as significant gravel resources cover at least 0.25 square miles (160 acres). The volume of a 50-foot-thick gravel unit of this size would be about 10 million cubic yards. Additionally, we map only those deposits that have minimum widths of 1,500 feet. As noted above, deposits with long, narrow map patterns are generally inefficient to operate. Although environmental issues are not considered herein, long narrow deposits are generally associated with rivers or streams where mining cannot take place owing to environmental considerations.

The surface area of each deposit was initially estimated using 1:100,000-scale geologic maps compiled by the Washington Division of Geology and Earth Resources (Schuster, 1994; Walsh, 1986) and other geologic maps (Bentley and others, 1980; Bentley and Campbell, 1983a,b; Campbell, 1976; Campbell and Gusey, 1992; Swanson, 1967; Swanson and Wright, 1978). The resulting polygons were modified where the portion of the deposit meeting the threshold criteria is less extensive than the mapped surface area of the deposit. Most of the geologic polygons depicted on this compilation contain existing mines or engineering tests of outcrops that prove at least some of the rock or sediment meets the threshold criteria. This approach, taken to expedite the inventory process, probably results in omission of a few significant resources.

OVERBURDEN—Only those deposits that have stripping ratios (ratios of overburden to gravel or overburden to rock) of less than 1 to 3 are included in this inventory. Overburden can cost from \$0.35 to more than \$1.50 per ton to remove. Typically, miners try to achieve a net profit of \$1.00 per ton, so the overburden volume must be much less than the volume of underlying aggregate if the mine is to be commercially viable. The stripping ratio can be larger where supply restrictions, favorable topography, or other considerations allow the overburden to be removed profitably. The largest stripping ratio for a profitable mine in Washington was 1 to 2, or 0.50.

The practice of topsoil sales and (or) synthesis is one method of profitably disposing of thicker organic or clay-rich overburden, but as a general rule, most overburden must be saved for reclamation (Norman and others, 1998; Norman and Lingley, 1992). Historically, few gravel deposits with more than 10 feet of overburden have been mined.

STRENGTH AND DURABILITY—In order to perform adequately as construction aggregate, gravel or bedrock must have high compressive strength and resist degradation when wet. Without these characteristics, the aggregate cannot support the weight of roads or buildings. Much of the vertical compressive strength, or load-bearing capacity, comes from grain-to-grain contact among individual pebbles that are effectively stacked up and prevented from shifting by cement and fine aggregate. Stronger aggregate commands a higher price, but weak rock is of no use. Minimum specifications for strength and durability of various rock products are published by the Washington State Department of Transportation in the Standard Specifications for Road, Bridge, and Municipal Construction, 2000 (Washington State Department of Transportation, 1999), a key reference book for the industry that is updated periodically. Specifications for gravel and bedrock are determined with laboratory tests including Los Angeles Abrasion, Degradation, Sand Equivalent, Specific Gravity, and Stabilometer tests (Appendix 1). Table 1 identifies some of the specifications required for certain uses of aggregate.

For this study, we inventory gravel and bedrock that meet WSDOT specifications for asphalt-treated base (Table 1). Asphalt-treated base is a compacted layer of aggregate treated with asphalt for stability and weatherproofing and placed directly on bulldozed earth or rock of the subgrade. The minimum acceptable test results are: Los Angeles Abrasion ≤30%, Degradation ≥15, Sand Equivalent ≥30%, specific gravity >1.95 grams per cubic centimeter, and weight percent passing a U.S. Standard No. 200 sieve <9%. If most of the deposit appears to meet these specifications, then we depict the entire deposit as meeting the strength and durability threshold criteria (Plate 1; Appendices 3 and 4).

OTHER CONSIDERATIONS—Typically, sand and gravel deposits should have a sand-to-gravel ratio of 40:60 and be free of weak or deleterious materials such as foliated metamorphic rock, poorly indurated clasts, clay, iron oxides, sulfides, glassy volcanic rock, and organic matter (Kroft, 1972; Washington State Department of Transportation, 1999).

SOURCES OF DATA

The locations of most mines in Washington are given in Lingley and Manson (1992). Data for existing and terminated mines are archived in Washington Department of Natural Resources permit files, Washington State Department of Transportation pit site files, and U.S. Forest Service mine files. The thicknesses of mined units, for example, are taken from Washington Department of Natural Resources Form SM-2 or from other permit-related documentation such as Environmental Impact Statements. The surface extent of geologic units are depicted on Washington Division of Geology and Earth Resources 1:100,000-scale geologic maps (Schuster, 1994; Walsh, 1986). Hydrology studies are particularly useful in assessing the stratigraphy of gravel deposits. Such reports are included in various types of environmental documentation, wellhead protection studies, and water resource reports. Logs of geotechnical bores (for example, bores for foundation engineering studies) are frequently useful. Water-well logs and some logs of geotechnical borings are archived by the Washington Department of Ecology and the Washington State Department of Transportation, respectively.

Appendix 3. Mine Database

This database contains information about most small active and terminated borrow pits or quarries and large active, terminated, and proposed mines in the Yakima 1:100,000 quadrangle. All of the borrow pits, quarries, and mines in this database are plotted on Plate 1. The information contained herein is available digitally as part of the geographic information system (GIS) files for the Yakima quadrangle. The columns that are not self-explanatory are defined as follows:

WADNR unique number – The Washington Department of Natural Resources (WADNR) unique number used by the geographic information system (GIS) to relate a feature on Plate 1 to a row in the database. The first four digits of the number identify the 7.5-minute quadrangle map in which the mine is located. The last four digits are a unique number in each 7.5-minute quadrangle.

WADNR data type code – The code number that indicates the type and size of the mine, as follows: 15 = small borrow pit or quarry (point); 16 = small terminated/depleted borrow pit or quarry (point); 18 = large active mine (polygon); 21 = large terminated/depleted mine (polygon); 22 = large proposed mine (polygon).

WADNR permit number – The five-digit number on Washington Department of Natural Resources Form SM-2, *Application for Surface Mining Reclamation Permit* (for a permitted mine).

WSDOT site number – The number assigned by the Washington State Department of Transportation (WSDOT) that links results of strength and durability testing to a particular mine. The number consists of a letter that identifies the county the site is in, followed by a sequentially assigned number.

¼ ¼ section, ¼ section, Section, Township, Range, Meridian – Legal description of the mine with reference to the Government Land Office grid. Townships and ranges are shown on Plate 1.

Product – The material being mined: rock, sand, or gravel.

Rock type – The type of rock that is being quarried at the site, if the mine is a quarry.

Geologic unit – The short label that identifies a particular unit on a geologic map. This field indicates the unit in which the mine is located as identified in Walsh (1986) and Schuster (1994), using the updated geologic unit labels consistent with Schuster (1994). Some units are described in Appendix 6.

Qualifier – Indicates either that the thickness shown in the adjacent column is exact because the mine penetrates all the way through the resource (blank) or that the actual resource thickness is greater than the thickness reported because the bottom of the resource was not identified (>).

Resource thickness (feet) – The thickness, in feet, of the sand, gravel, or bedrock that is being mined.

Million cubic yards – The estimated volume (in millions of cubic yards) of aggregate resource present within the permitted boundary of a mine as of November 2000.

Million tons – The reserve weight calculation based on reserve volume estimates. Conversion factors are 1.6 tons per cubic yard for sand and gravel, 2.4 tons per cubic yard for basalt and gabbro, and 2.2 tons per cubic yard for siliceous igneous rocks.

Acres – Typically the number of acres permitted on Washington Department of Natural Resources Form SM-2, *Application for Surface Mining Reclamation Permit*. For unpermitted mines, indicates the estimated area of the mine. Includes not only areas of aggregate extraction, but also all operations associated with the mine (stockpiling, crushing, screening, scales, etc.).

Percent depletion – The percentage by which the resource within the mine boundary has been depleted by mining, determined by communication with the mine operators or by field investigations.

Overburden thickness (feet) – The thickness, in feet, of soil, clay, or non-commercial aggregate that must be removed in order to reach the aggregate resource.

Stripping ratio – The overburden thickness divided by the resource thickness. A value of less than 0.33 (ratio of less than 1:3) is preferred.

Los Angeles Abrasion, Degradation, Specific Gravity, Sand Equivalent, and Stabilometer R Value tests – Results of laboratory tests, conducted mainly by the WSDOT, that reflect the quality of the deposit. See the glossary (Appendix 1) for explanation of tests.

Percent >2½ inches, Percent ¼–2½ inches, Percent <¼ inch, Percent <U.S. No. 200 sieve – Results of laboratory grain-size analysis of samples. Values are given in weight percent. The first three fields divide the whole sample, and the fourth field refers to the amount of silt and clay in the entire sample.

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit no.	WSDOT site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	section	Township (N)	Range	Merdian	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2.5 inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
20330001	15		E-252		Wiley		NW	9	12	15	E	Yakima	rock	basalt	Mv_{gR2}									13	88	2.7						
20340003	18	12938	E-241	Ahtanum quarry	Herke Rock	NE	NE	14	12	16	E	Yakima	rock	basalt	Mv_{wfs}		140	8	20	54	0	0	0.00	30	45	2.75	21					
20340002	15		E-307		E. Hammans	SW	NE	15	12	16	E	Yakima	rock	basalt	Mv_{wfs}		30			2		4	0.13	27	66	2.69						
20340005	15					SW	NE	15	12	16	E	Yakima	rock	basalt	Mv_{wfs}																	
20340008	15						SW	16	12	16	E	Yakima	gravel		Qa																	
20340001	15		E-313		Les Johnson	SW	NW	17	12	16	E	Yakima	gravel		Qa							2		20	79	2.71	60		30	51	19	0.6
20350002	15		E-37		Sinclair	SW	SE	3	12	17	E	Yakima	gravel		Rcg_t																	
20350001	15		E-36		Crabb and Borton	SE	NW	5	12	17	E	Yakima	gravel		Qa																	
20340006	15					SW	NW	6	12	17	E	Yakima	gravel		Rcg_t																	
20350004	18		E-303		Yakima Indian Agency	NE	SE	23	12	17	E	Yakima	rock	basalt	Mv_{wfs}		20					3	0.15	18	82	2.9						
20340004	21	11098			Earl Lewis	NE	NW	10	12	18	E	Yakima	gravel		Rcg_t					10	100	2										
20360002	15		E-240		Burrill	NE	SW	12	12	18	E	Yakima	gravel		Mc_e									27	57	2.56	53		39	52	9	0.9
20370035	21	10747	E-274		Morris	NE	SW	4	12	19	E	Yakima	gravel		Qa		25			7		2	0.08	16	75	2.73	57	72	0	49	51	4.6
20370008	15		E-33		T. H. Wheeler	NE	SE	5	12	19	E	Yakima	gravel		Qa																	
20370004	21	10794	E-345	Edler pit	Columbia Ready-Mix	E	NE	5	12	19	E	Yakima	gravel		Qa	>	25	0	0	110	100	6	0.24	17	79	2.71						
20370029	21		E-242		G. T. Wheeler	W	SE	5	12	19	E	Yakima	gravel		Qa									15	65	2.74	69	76	7	60	33	2.3
20370069	21					NE	NE	5	12	19	E	Yakima	gravel		Qa																	
20370068	21					NE	NE	8	12	19	E	Yakima	gravel		Qa																	
20370010	15		E-81			NW	NE	8	12	19	E	Yakima	gravel		Qa																	
20370030	21		E-244		Beautrow	W	SE	8	12	19	E	Yakima	gravel		Qa												8	43		1	99	50
20370104	22			Birchfield pit	Columbia Ready-Mix	SW	SW	10	12	19	E	Yakima	sand		Mc_e					42												
20370038	15					SW	SW	10	12	19	E	Yakima	sand		Mc_e																	
20370037	15		E-282		Deathrage Chapel	NW	SE	13	12	19	E	Yakima	gravel		Qafo		47			4.5							40	72	1	48	51	7.1
20370012	15		E-60			NE	NW	14	12	19	E	Yakima	gravel		Qaf									28								
20370003	18	12801	E-320	Anderson quarry	Columbia Ready-Mix	SW	SE	17	12	19	E	Yakima	rock	basalt	Mv_{sp}	>	25	2	5	20	50	0	0.00	15	80	2.9						
20370032	15		E-254		WSDOT	NW	NE	17	12	19	E	Yakima	gravel		Qa												77	76	9	56	35	7
20370028	18		E-239		Goldsmith	SE	SW	17	12	19	E	Yakima	gravel		Qa		20			13							78	71	24	58	18	0.9
20370002	15		E-16		Yakima Indian Agency		NW	17	12	19	E	Yakima	rock	basalt	Mv_w										48	2.74						
20370041	15		E-243		Masonic Temple	NW	NE	17	12	19	E	Yakima	rock	basalt	Mv_w																	
20370027	15		E-235	Thorp Road quarry	WSDOT	NW	NE	17	12	19	E	Yakima	rock	basalt	Mv_w		30					1	0.03									
20370039	15		E-314			NW	SW	17	12	19	E	Yakima	rock	basalt	Mv_w		80			1		2	0.02	17	66	2.85						
20370033	15		E-259			N	SE	18	12	19	E	Yakima	rock	basalt	Mv_w																	
20370067	21	10967		Parker pit	Parker Sand and Gravel	SE	NE	20	12	19	E	Yakima	gravel		Qa		15	0	0	35	100	0	0.00									

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit no.	WSDOT site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	section	Township (N)	Range	Merdian	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2.5 inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
20370014	18		E-101		Wash. Dept. of Fish and Wildlife	NE	NE	20	12	19	E	Yakima	gravel		Qa									14	75	2.74	54		7	71	22	2.6
20370015	18		E-104		Columbia Ready-Mix	E	SE	20	12	19	E	Yakima	gravel		Qa									18	83	2.73	70		26	55	19	0.1
20370001	15		E-14		Bradbury Fruit	NE	SW	21	12	19	E	Yakima	gravel		Qafo																	
20370011	15		E-84	Indian Allotment #2427		SE	NW	29	12	19	E	Yakima	gravel		Qa																	
20380005	15		E-120			NE	NE	13	12	20	E	Yakima	gravel		Qafo																	
20380004	15		E-119			SW	NW	14	12	20	E	Yakima	rock	basalt	Mv_{sp}		90	0	0		100	2	0.02									
20390011	15		E-122			SE	SE	17	12	21	E	Yakima	gravel		Qafo									20			30					
20400003	15		E-336			SE	NW	29	12	22	E	Yakima	rock	basalt	Mv_s									22	41	2.63						
20340007	15					SE	NE	25	13	16	E	Yakima	gravel		Rcg_t																	
19350001	18	12334		Summitview quarry	Ron Anderson	S	NW	10	13	17	E	Yakima	rock	basalt	Mv_{wfs}		50	2.5	6	65	35	6	0.12									
19350003	18	10444	E-34	Summitview quarry	Yakima County Public Works	NE	SW	11	13	17	E	Yakima	rock	basalt	Mv_{wfs}		50	0.8	2	56	50	1	0.02	31	52	2.79						
19360007	18		E-63		Fullbright	SE	SW	1	13	18	E	Yakima	gravel		Qa																	
19360008	21	11455	E-62		WSDOT	SW	NW	5	13	18	E	Yakima	gravel		Qa	>	20			40		0	0.00	14	76	2.73	80	57	35	42	23	1.4
19360037	18	10633	E-230	Long pit	Yakima County Public Works	NW	NW	5	13	18	E	Yakima	gravel		Qa		30	0.02	0.03	15		2	0.07									
19360006	21						NE	6	13	18	E	Yakima	gravel		Qa																	
19360011	15		E-200		WSDOT	NW	NE	9	13	18	E	Yakima	rock	basalt	Mv_{wpr}																	
19360001	15		E-222		Garretson	SW	NE	9	13	18	E	Yakima	gravel		Qa																	
20360001	18	10317		Wachsmith pit	Columbia Ready-Mix	SE	SE	10	13	18	E	Yakima	gravel		Qa		25	0	0	19.15	100	3	0.12									
20360005	21		E-281		Triangle Sand and Gravel	E	SE	10	13	18	E	Yakima	gravel		Qa		10			3	100	1	0.10	17	79	2.76	80		37	46	17	0.7
20360004	21		E-197		WSDOT	SE	SE	10	13	18	E	Yakima	gravel		Qa									18	78	2.72		75	35	43	22	1.3
19360005	15		E-13		Pacific Power and Light	NE	SW	10	13	18	E	Yakima	gravel		Qa																	
19360017	15		E-263	Dawson #1		NW	NE	12	13	18	E	Yakima	rock	basalt	Mv_w																	
19360009	15		E-135		WSDOT	SE	NE	12	13	18	E	Yakima	gravel		Qa		8							12	78	2.86						
19360010	21					NE	NW	12	13	18	E	Yakima	gravel		Qa																	
19360012	21		E-211	Berglund Lake	WSDOT	NE	SE	12	13	18	E	Yakima	gravel		Qa		30										70	77	16	41	43	3.9
19360019	21		E-268		WSDOT	NW	SW	12	13	18	E	Yakima	gravel		Qa		25			10	100	0	0.00	14	73	2.78	60	79	29	59	15	1.1
19360014	15		E-224	Dawson pit	WSDOT	SW	NE	12	13	18	E	Yakima	gravel		Qa													76				
20360030	21	11519	E-144		Northwest Construction	NE	NE	14	13	18	E	Yakima	gravel		Qa		27	0	0	55	100	2	0.07	15	76	2.78	74	78	25	54	31	1.2
20360006	15		E-280		Darby	NE	NW	15	13	18	E	Yakima	gravel		Qt		30			2		1	0.03				58	79	0	71	29	1.5
19360004	18	12774		Rowley pit	Superior Asphalt and Concrete	SW	NW	6	13	19	E	Yakima	rock	basalt	Mv_w		200	2.9	7	62		0	0.00									

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit no.	WSDOT site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	section	Township (N)	Range	Merdian	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2.5 inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
19370013	18	10045	E-217		WSDOT	NE	SW	7	13	19	E	Yakima	gravel		Qa		15		0.9			1	0.07	14.8	73	2.76	88	79	6	58	36	1.1
19360016	15		E-264	Dawson #2		SW	NW	7	13	19	E	Yakima	rock	basalt	Mv_{w}																	
19370019	18	12908	E-260	Rest Haven riprap	Columbia Ready-Mix	NW	SE	7	13	19	E	Yakima	rock	basalt	Mv_{w}		290	0.8	2	9	60	0	0.00	15	77	2.75			1	64	35	
20370063	15	12202		Rosa Hill	Yakima County Public Works	NE	SW	13	13	19	E	Yakima	rock		Mc_{e}		50		0.1	2		0	0.00									
20370018	21		E-155		WSDOT	NE	SW	17	13	19	E	Yakima	gravel		Qa									12.3		2.79	83	78	23	47	30	3
20370009	21	10198	E-136	Beech Street pit	Central Pre-Mix	E	SE	20	13	19	E	Yakima	gravel		Qa		130	0	0	84	100	0	0.00	28	45	2.75		73				
20370013	15		E-99		City of Yakima	SE	NW	20	13	19	E	Yakima	gravel		Qt																	
20370024	15		E-231		Buchanan	NE	SW	20	13	19	E	Yakima	gravel		Qt													75				
20370071	21					S	S	21	13	19	E	Yakima	gravel		Qa																	
20370019	15		E-165		Yakima County	NE	SW	21	13	19	E	Yakima	gravel		Qt									14		2.75						
20370020	21		E-177		WSDOT	SW	SW	27	13	19	E	Yakima	gravel		Qa		20			14		3	0.15	17.5	70	2.69			19	56	25	1.5
20370062	18	10351		Meyer's pit	Yakima County Public Works	SE	SW	28	13	19	E	Yakima	gravel		Qa		30			16		2	0.07									
20370016	15		E-127		Meyer	NE	SW	28	13	19	E	Yakima	gravel		Qa									12	74	2.74	70		28	57	15	0.6
20370036	18		E-276		R. S. Meyers	NW	SW	28	13	19	E	Yakima	gravel		Qa		20					3	0.15	19.1	79	2.68	52		52	44	4	0.6
20370025	18		E-233		J. P. Surface Co.	NE	SE	29	13	19	E	Yakima	gravel		Qa					2												
20370007	15		E-26		First Security and Loan	SW	NW	30	13	19	E	Yakima	gravel		Qt																	
20370026	18		E-234		City of Yakima	SE	NE	32	13	19	E	Yakima	gravel		Qa													75				
20370006	18	11434	E-273	Newland pit	Central Pre-Mix	NE	NW	33	13	19	E	Yakima	gravel		Qa		85	0.3	0.5	70	80	0	0.00	15.1	77	2.75						
20370005	18	11513		Riverside pit	Central Pre-Mix	NE	SW	33	13	19	E	Yakima	gravel		Qa		25	0.75	1.2	40	10	2	0.08									
20370022	21		E-203		WSDOT	NW	SW	33	13	19	E	Yakima	gravel		Qa		12							16	79	2.74	60	75	11	56	23	2.3
20370216	18	11151	E-187		WSDOT	NE	NW	33	13	19	E	Yakima	gravel		Qa	>	20					0	0.00	17	77	2.77		76	18	61	21	0.8
20370021	22			East Valley gravel mine	Central Pre-Mix	W	SW	34	13	19	E	Yakima	gravel		Qa		80	7.5	12	291	0											
20380001	18	12818		Lewis shale pit	Lewis Construction	SW	SE	7	13	20	E	Yakima	rock	basalt	Mv_{se}		90	0.25	0.6	20.75	20	0	0.00									
20380002	18	12796		Champoux shale pit	Gerald Champoux	SW	SW	8	13	20	E	Yakima	rock	basalt	Mv_{se}		100	0.17	0.4	18	60	0	0.00									
20380003	18	12000	E-326	Champoux quarry	Mark/Gerald Champoux	NE	SW	17	13	20	E	Yakima	rock	basalt	Mv_{s}		40			15		1	0.02	18	65	2.62						
20380007	21	11025	E-275	Bohoski pit	Yakima County Public Works	NW	SW	17	13	20	E	Yakima	rock	basalt	Mv_{s}		90					2	0.02	16	19	2.72						
19330004	15		E-75		U.S. Forest Service	SE	SW	13	14	15	E	Yakima	gravel		Qa																	
19330005	21		E-161		Northern Pacific Railroad	NW	NE	13	14	15	E	Yakima	gravel		Qls					23		1		14	85	2.6						
19330007	15				U.S. Forest Service	SW	NE	14	14	15	E	Yakima	rock	basalt	Mv_{gN2}																	

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit no.	WSDOT site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	section	Township (N)	Range	Merdian	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2.5 inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
19330001	15		E-40		Snoqualmie National Forest	W	SW	22	14	15	E	Yakima	gravel	volcanics	Mva$_{fp}$																	
19330006	15		E-175		Northern Pacific Railroad	SE	NE	22	14	15	E	Yakima	gravel		Qls									18		2.78						
19330002	15		E-42		U.S. Forest Service	NW	SE	30	14	15	E	Yakima	gravel	volcanics	Mva$_{fp}$																	
19340006	15		E-272		Washington Game Department	NW	NE	2	14	16	E	Yakima	rock	basalt	Mv$_{gN2}$		100							19	82	2.73						
19340004	21	11149	E-154		WSDOT	SE	NW	2	14	16	E	Yakima	gravel		Qa					12				22	67	2.73	63		17	49	34	1.7
19340007	15		E-327		Washington Game Department	S	SW	3	14	16	E	Yakima	rock	basalt	Mv$_{gN2}$							1		27	56	2.65						
19340001	15		E-44		W. H. West		SW	8	14	16	E	Yakima	rock	basalt	Mv$_{gN2}$																	
19340005	18		E-146	Oak Creek pit	Washington Game Department	NW	NE	9	14	16	E	Yakima	rock	andesite	Qva$_{tl}$																	
19340002	15		E-39		Addison Cobb	W	NW	10	14	16	E	Yakima	rock	basalt	Mv$_{gN2}$																	
19340008	18	11600		Caton quarry	Yakima County Public Works		S	23	14	16	E	Yakima	rock	basalt	Mv$_{gN2}$		100			10		1	0.01									
19330003	15		E-43		W. H. West	SW	NW	23	14	16	E	Yakima	rock	basalt	Mv$_{gN2}$																	
19350005	21		E-46		WSDOT		SW	4	14	17	E	Yakima	gravel		Qa		30			14									20	62	18	
19350008	15		E-64			SE	SE	4	14	17	E	Yakima	gravel		Qa																	
19350007	16		E-47		Hayes	SE	NW	5	14	17	E	Yakima	gravel		Qa														6	86	8	0.5
19350018	16	10724	E-286		Riddle	NE	NW	9	14	17	E	Yakima	rock	andesite	Qva$_{tl}$		75			3					65	2.56						
19350002	15					SE	NE	9	14	17	E	Yakima	gravel		Qt																	
19350009	16		E-89		McPhee	SE	SW	11	14	17	E	Yakima	gravel		Qa											2.64			4	53	43	
19350012	21	10692	E-225		J. A. Tartelin and Sons	NW	SW	11	14	17	E	Yakima	gravel		Qa									19	75	2.74	81	78	22	57	21	0.6
19350019	21	10878	E-287		Ordeco	SW	NE	14	14	17	E	Yakima	gravel		Qa		10			5	100	2	0.20	16	73	2.82	36	72	55	22	23	3.2
19350004	15		E-35		Hatton	SW	SW	17	14	17	E	Yakima	rock	andesite	Qva$_{tl}$																	
19350016	21	10757	E-278		Stephens	NE	SW	23	14	17	E	Yakima	rock	andesite	Qva$_{tl}$		30			5		0	0.00									
19350010	15		E-147			SE	NW	24	14	17	E	Yakima	rock	basalt	Mv$_{sp}$																	
19350011	21		E-210		L. T. Hass	NW	SW	24	14	17	E	Yakima	gravel		Qa					23				20	75	2.74	62	69	8	39	53	6.4
19350015	21		E-277		Hahn	W	NW	24	14	17	E	Yakima	gravel		Qa													77	16	51	33	1.9
19350006	16		E-45		Cloverdale	SE	NE	25	14	17	E	Yakima	gravel		Qa		15												20	59	21	
19350017	21		E-279		Page	W	SE	25	14	17	E	Yakima	gravel		Qa							2					50	80	18	54	28	2
19350013	15		E-258		Albrecht		NE	26	14	17	E	Yakima	rock	andesite	Qva$_{tl}$		75															
19360002	15					SE	SW	35	14	18	E	Yakima	rock		Mc$_{e}$																	
19360036	22	12846		Monson pit	Central Pre-Mix		NE	36	14	18	E	Yakima	gravel		Qa		40	4.4	7	215	0	0	0.00									
19370014	18	10052	E-265		WSDOT	NE	NW	11	14	19	E	Yakima	rock	basalt	Mv$_{sp}$		80		2.6	37.5	10			18	36	2.8						
19370007	15		E-181		WSDOT	W	NE	17	14	19	E	Yakima	gravel		Qt		25					3	0.12	16	62	2.75	51		21	59	20	1.4
19370002	15		E-126		Harrison	SE	SE	19	14	19	E	Yakima	gravel		Qa																	
19370018	21	10769			Superior Asphalt and Concrete	NE	NE	30	14	19	E	Yakima	gravel		Qa		21	0	0	2	100											

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit no.	WSDOT site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	section	Township (N)	Range	Merdian	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2.5 inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
19360040	21	10750			Superior Asphalt and Concrete	NW	NW	30	14	19	E	Yakima	rock	basalt	Mv_{sp}		11	0	0	3	100	0	0.00									
19360039	21	10719			Superior Asphalt and Concrete	SE	NW	30	14	19	E	Yakima	gravel		Qa		18	0	0	8	100	1	0.06									
19370010	21		E-255	East Selah complex	WSDOT	NE	SE	31	14	19	E	Yakima	gravel		Qa					47	100			16	74	2.75	73	76	33	56	23	0.7
19370009	15		E-245		WSDOT	SW	SE	31	14	19	E	Yakima	gravel		Qa		20					3	0.15	13	72	2.57		79				
19370003	18	10175	E-141	Selah pit	Central Pre-Mix		SW	31	14	19	E	Yakima	gravel		Qa		30	0.6	1	320	95	0	0.00	16	68	2.76		74				
19370001	18		E-11		Yakima Cement Products	SE	SW	31	14	19	E	Yakima	gravel		Qa																	
19370006	18		E-132		Rose	SW	NE	31	14	19	E	Yakima	gravel		Qa									19	73	2.77	79	76	7	63	30	1.2
19370005	21		E-128		Romano	NE	NE	31	14	19	E	Yakima	gravel		Qa									15								
19370040	15					SE	SW	32	14	19	E	Yakima	rock		Mc_{e}																	
18330009	15		E-319	Nile talus	WSDOT	NE	SW	2	15	15	E	Yakima	rock	basalt	Mv_{gR2}		50			11		0	0.00	21	87	2.79						
18330002	15					SE	SW	2	15	15	E	Yakima	gravel		Qa																	
18330001	18	12365	E-86	Little rock pit	Alfred Simmons	SW	SE	2	15	15	E	Yakima	rock	basalt	Mv_{gR2}		150		0.8	50	25	0	0.00	16	83	2.81						
18330003	15		E-50		Hanskutt	NE	NE	3	15	15	E	Yakima	gravel		Qa														14	62	24	3
19330008	15				Washington Game Department	SW	SE	35	15	15	E	Yakima	gravel		Qls																	
18340001	18	10881	E-289	Horseshoe Bend	Ken Williamson	NE	SE	28	15	16	E	Yakima	rock	basalt	Mv_{gR2}		160	1.1	2.7	20	50	0	0.00	18	92	2.72						
18350004	15					SW	SE	2	15	17	E	Yakima	rock	basalt	Mv_{wfs}																	
18350007	15					NE	NW	3	15	17	E	Yakima	rock	basalt	Mv_{wfs}																	
18350002	18	12347	E-329	Wenas pit	Yakima County Public Works	NE	SW	12	15	17	E	Yakima	gravel		Qa		12			6		0	0.00	18	79	2.81						
18350003	15					SE	NW	12	15	17	E	Yakima	rock	basalt	Mv_{wfs}																	
18350001	15					NE	SW	12	15	17	E	Yakima	gravel		Qa																	
18350008	15					NW	NE	36	15	17	E	Yakima	gravel		Mc_{e}																	
18360001	15				Washington Game Department	SE	NE	3	15	18	E	Yakima	rock	basalt	Mv_{wfs}																	
18370007	15		S-3			NE	SE	4	15	19	E	Kittitas	rock	basalt	Mv_{gN2}																	
18370009	16	11503		Squaw Creek	Kittitas County Public Works	NE	SE	4	15	19	E	Kittitas	rock	basalt	Mv_{gN2}			0	0	3	100											
18370004	15		S-77		WSDOT	SW	SW	9	15	19	E	Kittitas	gravel		Qa		9							16	77	2.75	66	76	4	52	44	2.6
18370005	15		S-13			NW	NW	10	15	19	E	Kittitas	gravel		Qa														4			
18370006	21		S-108		WADNR	NE	NW	16	15	19	E	Kittitas	gravel		Qa		8							11	72	2.83	83	77	34	38	28	1.1
18370010	16					SW	NE	17	15	19	E	Kittitas	rock	basalt	Mv_{wfs}																	
18370002	18		S-202		WSDOT	SE	NE	21	15	19	E	Kittitas	gravel		Qa									13	78	2.82	65		26	55	19	1.1
18370003	21		S-234		WSDOT		SE	24	15	19	E	Kittitas	rock	basalt	Mv_{gN2}		40							15	88	2.81						
18380001	15		S-258			S	NE	7	15	20	E	Kittitas	rock	basalt	Mv_{gN2}		50							14	84	2.87						
17330005	15				U.S. Forest Service	SW	NW	2	16	15	E	Yakima	rock	basalt	Mv_{gN2}																	

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17330002	15		E-52			NE	SE	7	16	15	E	Yakima	rock	volcanics	Mva$_{fp}$																	
17330001	15		E-51			NE	NW	17	16	15	E	Yakima	gravel		Qa																	
17330004	15		E-148			NE	NE	17	16	15	E	Yakima	rock	volcanics	Mva$_{fp}$																	
17330003	15		E-126			SE	SW	17	16	15	E	Yakima	rock	volcanics	Mva$_{fp}$									17								
18330005	15		E-87		Valentine	NW	SE	21	16	15	E	Yakima	gravel		Qa														14	69	17	
18330010	15				U.S. Forest Service	NE	NW	24	16	15	E	Yakima	rock	basalt	Mv$_{gN2}$																	
18330004	18		E-74		WSDOT	SW	SW	27	16	15	E	Yakima	rock	basalt	Mv$_{gR2}$		200					0	0.00	17	85	2.81						
18330007	15		E-236		WSDOT	SE	NE	28	16	15	E	Yakima	gravel		Qa									14	59	2.71	56		42	40	18	0.9
18330006	15		E-88		Perry	SE	NE	28	16	15	E	Yakima	gravel		Qa									12		2.76	73		44	34	22	0.9
18330008	18		E-257		WSDOT	NW	NW	34	16	15	E	Yakima	gravel		Qa							1		21	76	2.79	44		44	37	19	1.1
19340003	15					SE	SW	12	16	16	E	Yakima	gravel		Mc$_{e}$																	
18340002	15					NE	SW	13	16	16	E	Yakima	gravel		Qa																	
17340002	15					NE	SW	13	16	16	E	Yakima	gravel		Mc$_{e}$																	
17340003	15					NE	SW	13	16	16	E	Yakima	gravel		Mc$_{e}$																	
17350005	15	11289		Manastash pit	Boise Cascade	NE	SW	5	16	17	E	Kittitas	rock	basalt	Mv$_{gN2}$					3	100											
18350005	15					SE	SE	34	16	17	E	Kittitas	gravel		Qa																	
18350006	15					SW	SE	34	16	17	E	Kittitas	gravel		Qa																	
17360010	15		S-11		Chambers	SW	SW	2	16	18	E	Kittitas	rock	basalt	Mv$_{gN2}$																	
18370008	18	10048	S-235		WSDOT		SW	26	16	19	E	Kittitas	rock	basalt	Mv$_{gN2}$				0.72	56				20.3	60	2.68						
18370001	15		S-164		Northern Pacific Railroad	NE	NW	29	16	19	E	Kittitas	gravel		Qa		10							13.6	71	2.79	84		28	50	22	0.9
17330006	15				U.S. Forest Service	NE	SW	33	17	15	E	Kittitas	rock	basalt	Mv$_{gN2}$																	
17340001	15		S-215		O'Bannon	SE	SE	24	17	16	E	Kittitas	rock	basalt	Mv$_{gN2}$									13	78	2.75						
17350003	15		S-278		Michael Cole	SE	NE	12	17	17	E	Kittitas	gravel		Qa													77				
17350004	16	11034			L. E. Dolman	NE	NE	13	17	17	E	Kittitas	gravel		Qa		30	0	0	10	100	0	0.00									
17350002	15		S-250		Frita Olds	NW	NE	14	17	17	E	Kittitas	rock	basalt	Mv$_{gN2}$		100					0	0.00	17.8	61	2.68						
17350006	15					NE	NE	15	17	17	E	Kittitas	rock	basalt	Mv$_{gN2}$																	
17360032	15		S-275	Dollar Way		E	NW	3	17	18	E	Kittitas	gravel		Qa									14		2.73						
17360005	21					SW	NE	3	17	18	E	Kittitas	gravel		Qa									15	63	2.75						
17360003	21		S-171	Carey Lakes	WSDOT	NW	SE	3	17	18	E	Kittitas	gravel		Qa									16	68	2.76	51	80	19	60	21	2.9
17350001	15		S-279			SW	NW	7	17	18	E	Kittitas	gravel		Qa												34		25			
17360006	21		S-34		Kittitas County Public Works	SW	NE	10	17	18	E	Kittitas	gravel		Qa											2.67						
17360036	21		S-190	Eaton pit		S	NW	11	17	18	E	Kittitas	gravel		Qa					54				15	65	2.78	57	74	22	57	21	7
17360035	21		S-232	Sorenson pit	Howard Sorenson	NW	SW	12	17	18	E	Kittitas	gravel		Qa	>	12	0	0	20	100						21		34	51	15	2.4
17360007	15		S-59		Albert Tjossem	NW	SE	12	17	18	E	Kittitas	gravel		Qa											2.67			2			
17360034	21		S-240		Bull	SE	SE	12	17	18	E	Kittitas	gravel		Qa												16	61	20	51	29	6.2
17360012	18		S-91		WSDOT	S	SE	13	17	18	E	Kittitas	gravel		Qa									10.9		2.74	58		28	51	21	0.9

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17360008	21		S-15		Gabert	NE	SW	13	17	18	E	Kittitas	gravel		Qa																	
17360014	15		S-89			SE	NW	13	17	18	E	Kittitas	gravel		Qa																	
17360038	18	10150	S-161	Hansen pit	Kittitas County Public Works		SW	13	17	18	E	Kittitas	gravel		Qa	>	14	0.3	0.48	40	80	2	0.14	13	67	2.74	73	80	0	66	34	1.4
17360031	21		S-242		H. Sorenson	NW	SE	13	17	18	E	Kittitas	gravel		Qa	>	20					1.5	0.08	18	75	2.76	50	76	9	68	23	1.6
17360025	15		S-282			NW	NW	14	17	18	E	Kittitas	gravel		Qa																	
17360028	21		S-225		Eaton	E	NW	14	17	18	E	Kittitas	gravel		Qa							1.5		11	74	2.73	67	79	23	64	13	0.9
17360024	15		S-251		Ellensburg Cement Products	W	NW	14	17	18	E	Kittitas	gravel		Qa									16	61	2.75						
17360015	15		S-82			NE	NE	15	17	18	E	Kittitas	gravel		Qa																	
17360002	18	12825		Stone Quarry Canyon pit	Ellensburg Cement Products	SW	SW	16	17	18	E	Kittitas	gravel		QPcg		60			20	10	0	0.00									
17360004	15		S-303		Ray Thayer	NW	NW	21	17	18	E	Kittitas	rock	basalt	Mv_{gN2}									22	53	2.75						
17360033	15		S-252		McAusland	SE	SE	24	17	18	E	Kittitas	gravel		Qa	>	15					1	0.07	18	68	2.75	88		7	59	34	0.7
17360037	18	10051	S-226	S-226 and S-213	WSDOT		NE	24	17	18	E	Kittitas	gravel		Qa				2.1	65	0			11	66	2.76	92	79	11	58	31	1
17360013	21		S-90		Ellensburg Cement Products	NE	SE	24	17	18	E	Kittitas	gravel		Qa									11		2.76			13	61	26	1.6
17360016	15		S-124			SE	SE	25	17	18	E	Kittitas	gravel		Qa												82	81	5	67	28	1.1
17360029	15					SW	NE	25	17	18	E	Kittitas	gravel		Qa																	
17360001	18	12858		Thayer riprap	Ellensburg Cement Products	SW	SE	27	17	18	E	Kittitas	rock	basalt	Mv_{gN2}		60			18	40	0	0.00									
17360009	16	11705	S-14		Kittitas County Public Works	SW	SW	30	17	18	E	Kittitas	gravel		Qa	>	12			1.5		2	0.17	13	67	2.72	62	79	8	71	21	1.1
17360023	15		S-227				SE	33	17	18	E	Kittitas	sand		Mc_e												75				100	28
17370008	15		S-98			SW	NW	2	17	19	E	Kittitas	gravel		Qaf									23					8			
17370006	15		S-188		Clerf	SE	SE	7	17	19	E	Kittitas	gravel		Qaf	>	20										28	59	10	38	52	15
17370002	15		S-246			NW	SE	8	17	19	E	Kittitas	gravel		Qaf	>	10										22	69	28	58	14	2.4
17370005	21		S-182		WSDOT	SE	SW	10	17	19	E	Kittitas	gravel		Qaf												12	45	28	48	24	6.7
17370001	21		S-244		Max Kuney	SW	SE	12	17	19	E	Kittitas	gravel		Ql	>	10										25	69	9	53	38	8.4
17370007	15		S-100			SE	NW	15	17	19	E	Kittitas	gravel		Qaf									20					19	48	33	9.6
17360026	15		S-241		Poulson	NW	NE	18	17	19	E	Kittitas	sand		Ql	>	25										36	59	0	27	73	10
17360017	15		S-109			NW	SW	19	17	19	E	Kittitas	gravel		Qa									12		2.81	86	75	27	49	24	0.5
17360039	21	10163	S-254	Fiorito pond	Northwest Construction	SW	NE	30	17	19	E	Kittitas	gravel		Qa		20	0	0	15	100	1	0.05	13	78	2.8	82		7	59	34	1
17360027	21		S-236		Ellensburg Cement Products	NW	NE	31	17	19	E	Kittitas	gravel		Qa							1		16	70	2.8	60	76	8	54	36	2.5
17370003	16		S-228		George Hodges	NE	NE	31	17	19	E	Kittitas	gravel		Qa		40					1	0.02				32	60	5	26	69	28
17380005	15		S-60			W	SE	2	17	20	E	Kittitas	rock	basalt	Mv_{wfs}																	
17380009	15		S-1		WSDOT	SW	NE	5	17	20	E	Kittitas	rock	basalt	Mv_{wfs}																	
17380008	15		S-33			SE	NE	5	17	20	E	Kittitas	rock	basalt	Mv_{wfs}																	
17380002	21		S-201			SW	SW	8	17	20	E	Kittitas	gravel		Qa												46	67	27	50	23	3.7

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17380006	21	11064	S-104		Kittitas County Public Works	NW	SW	10	17	20	E	Kittitas	rock	basalt	Mv_{wfs}									18								
17380007	15		S-239		Kittitas County Public Works	SE	NW	10	17	20	E	Kittitas	rock	basalt	Mv_{wfs}									13	73	2.9						
17380014	18	12905		Bennett pit	Kittitas County Public Works	SE	NW	10	17	20	E	Kittitas	rock	basalt	Mv_{wfs}		30	0.1	0.24	7		0	0.00	14	73	2.8						
17380011	18	10728	S-245	Kern pit	Kittitas County Public Works	SW	SW	15	17	20	E	Kittitas	rock	basalt	Mv_{wfs}		100	0.1	0.24	24.5	60			16	44	2.68	34			11		
17380004	15		S-203		WSDOT	SW	NE	17	17	20	E	Kittitas	gravel		Rcg_t									21	45	2.63						
17380013	18	12785		Clerf quarry	Ellensburg Cement Products		NW	17	17	20	E	Kittitas	rock	basalt	Mv_{gN2}		30			12	35	6	0.20									
17380012	18	11971	S-261	Saddle Mountain pit	Kittitas County Public Works	NE	SW	7	17	21	E	Kittitas	rock	basalt	Mv_{wfs}		10	0.1	0.24	17	40	0	0.00	16	82	2.88						
17390005	15		S-9		Rothrock	SW	SE	9	17	21	E	Kittitas	rock	basalt	Mv_{wfs}		25															
17390004	15		S-32			N	NW	9	17	21	E	Kittitas	rock	basalt	Mv_{wfs}																	
17390002	15		S-62		Smithson Co.	SW	NW	14	17	21	E	Kittitas	rock	basalt	Mv_{gN2}																	
17390007	18	11686	S-214	Ryegrass quarry	WSDOT	NW	SE	21	17	21	E	Kittitas	rock	basalt	Mv_{wfs}		40		0.36	11		1	0.02	29	63	2.78						
17390001	21		S-194			E	NE	28	17	21	E	Kittitas	rock	basalt	Mv_{wfs}		25					5	0.20	12	73	2.87						
17400002	15		S-31			SE	SW	18	17	22	E	Kittitas	rock	basalt	Mv_{wfs}																	
17400004	21		S-30			NW	SE	21	17	22	E	Kittitas	rock	basalt	Mv_{gN2}									10	83	2.79						
17400003	15		S-29			NE	SW	23	17	22	E	Kittitas	rock	basalt	Mv_{gN2}																	
17400001	18		S-196			SE	NE	29	17	22	E	Kittitas	rock	basalt	Mv_{wr}									15.8	80	2.88						
17390006	15		S-217		WADNR	NW	NW	30	17	22	E	Kittitas	rock	basalt	Mv_{gN2}		25															

Appendix 4. Outcrop Database

This database contains information about outcrops on which strength and durability testing was performed, but mining did not take place. These locations are plotted on Plate 1. The information contained herein is available digitally as part of the geographic information system (GIS) files for the Yakima 1:100,000 quadrangle. The columns that are not self-explanatory are defined as follows:

WADNR unique number – The Washington Department of Natural Resources (WADNR) unique number used by the geographic information system (GIS) to relate a feature on Plate 1 to a row in the database. The first four digits of the number identify the 7.5-minute quadrangle map in which the outcrop is located. The last four digits are a unique number on each 7.5-minute quadrangle.

WADNR data type code – The code number that indicates the type of investigation, as follows: 13 = strength and durability outcrop test location (point).

WSDOT site number – The number assigned by the Washington State Department of Transportation (WSDOT) that links results of strength and durability testing to a particular outcrop. The number consists of a letter that identifies the county the site is in, followed by a sequentially assigned number.

¼ ¼ section, ¼ section, Section, Township, Range, Meridian – Legal description of the outcrop with reference to the Government Land Office grid. Townships and ranges are shown on Plate 1.

Product – The material of interest at the location: rock, sand, or gravel.

Rock type – The type of rock at the location, if the outcrop is a bedrock unit.

Geologic unit – The short label that identifies a particular unit on a geologic map. This field indicates the unit in which the outcrop is located as identified in Walsh (1986) and Schuster (1994), using the updated geologic unit labels consistent with Schuster (1994). Some units are described in Appendix 6.

Qualifier – Applies only to the deepest resource thickness reported (see following columns) and indicates either that the thickness is exact because the whole section could be measured (blank) or that the actual resource thickness is greater than the thickness reported because the bottom of the resource was not identified (>).

1st resource thickness (feet), 1st interbed thickness (feet), 2nd resource thickness (feet) – These fields refer to the bedding identified in the outcrop by the authors, starting at the top. 'Resource thickness' refers to the thickness of a likely aggregate resource, whereas 'interbeds' are non-commercial materials such as silt and clay.

Dip, Strike – Indicate orientation of sedimentary bedding in a bedrock resource; if horizontal or no data, fields are blank.

Induration – The relative quality of a rock as determined in the field with a one-pound ball peen hammer. Estimates range from rebound (highest quality) through fracture, pit, and dent (lowest quality).

Overburden thickness (feet) – Thickness, in feet, of soil, clay, or non-commercial aggregate that must be removed in order to reach the aggregate resource.

Stripping ratio – The overburden thickness divided by the resource thickness. A value of less than 0.33 (ratio of less than 1:3) is preferred.

Los Angeles Abrasion, Degradation, Specific Gravity, Sand Equivalent, and Stabilometer R Value tests – Results of laboratory tests, conducted mainly by the WSDOT, that reflect the quality of the deposit. See the glossary (Appendix 1) for explanation of tests.

Lab (L) or visual (V) – This code indicates whether grain-size analysis is from a laboratory test (L) or estimated visually in the field (V).

Percent >2½ inches, Percent ¼–2½ inches, Percent <¼ inch, Percent <U.S. No. 200 sieve – Results of laboratory grain-size analysis of samples. Values are given in weight percent. The first three fields divide the whole sample, and the fourth field refers to the amount of silt and clay in the entire sample.

IDENTIFIER				LOCATION							MATERIAL							QUALITY														
WADNR unique number	WADNR data type code	WSDOT site number	Site name/ description	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Product	Rock type	Geologic unit	Qualifier	1st resource thickness (feet)	1st interbed thickness (feet)	2nd resource thickness (feet)	Dip	Strike	Induration	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Lab (L) or Visual (V)	Percent >2½ inches	Percent ¼–2.5 inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
19350014	13	E-261	Howley	SW	NW	6	13	18	E	Yakima	rock	andesite	Qva$_{tl}$																			

Appendix 5. Well Database

This database contains information about all water wells and geotechnical bores that are plotted on Plate 1. The information contained herein is available digitally as part of the geographic information system (GIS) files for the Yakima 1:100,000 quadrangle. The columns that are not self-explanatory are defined as follows:

WADNR unique number – The Washington Department of Natural Resources (WADNR) unique number is used by the geographic information system (GIS) to relate a feature on Plate 1 to a row in the database. The first four digits of the number identify the 7.5-minute quadrangle map in which the well is located. The last four digits are a unique number on each 7.5-minute quadrangle.

WADNR data type code – The code number that indicates the type of drill hole, as follows: 11 = water well (point); 12 = geotechnical or other bore (point).

WADOE well number – One of a variety of numbers found on the Washington Department of Ecology (WADOE) water-well report forms. The possible types include start card, application, or permit numbers.

Data verified? – Relates to the quality of data. 'Y' indicates that the drill log is from a geotechnical bore or has been verified by a consulting firm; otherwise, the field is blank.

Well location – Gives the street address of the well or the nearest geographical feature. Washington State Department of Transportation bores are referenced to the bridge, intersection, or street location where the bore is drilled.

¼ ¼ section, ¼ section, Section, Township, Range, Meridian – Legal description of the well with reference to the Government Land Office grid. Townships and ranges are shown on Plate 1.

Geologic unit – The short label that identifies a particular unit on a geologic map. This field indicates the unit in which the well is located on the surface as identified in Walsh (1986) and Schuster (1994), using the updated geologic unit labels consistent with Schuster (1994). Some units are described in Appendix 6.

Qualifier – Applies only to the deepest gravel thickness reported (see following columns) and indicates that either the thickness is exact because the whole layer is penetrated by the well (blank) or that the actual gravel thickness is greater than the thickness reported because the bottom of the gravel was not identified in the well log (>).

Overburden thickness (feet) – The thickness, in feet, of soil, clay, or non-commercial aggregate that must be removed in order to reach the aggregate resource.

1st gravel thickness (feet), 1st interbed thickness (feet), 2nd gravel thickness (feet), 2nd interbed thickness (feet), 3rd gravel thickness (feet) – These fields refer to the interpretation of the well log by the authors, starting at the ground surface. 'Gravel thickness' refers to the thickness of a likely aggregate resource, whereas 'interbeds' are non-commercial materials such as silt and clay.

Depth to water-bearing zone (feet) – Gives depth, in feet, to top of the first water-bearing unit encountered during drilling.

Bedrock penetrated? – This column contains either a Y (yes), N (no), or blank (unknown) indicating whether or not the well was drilled to the depth of bedrock.

Reference – The source of data for the well log, if other than the Washington Department of Ecology water-well log archives.

IDENTIFIER						LOCATION									WELL LOG										
WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well total depth (feet)	Bedrock penetrated?	Reference
20340013	11				Catholic Mission			NE	13	12	16	E	Yakima	Qa		2	17						195	Y	
20340012	11				James Nance		SE	NW	17	12	16	E	Yakima	Qa		3	56						285	Y	
20340010	11				Paul Hinson	South Fork	SE	NE	18	12	16	E	Yakima	Qa		2	51						435	Y	
20340011	11				Clayton Marshal	171 Ahtanum Road South Fork	NE	NE	18	12	16	E	Yakima	Qa		14	34						150	Y	
20340009	11				Patricia Patterson	101 AhtanumRoad South Fork	NW	NE	18	12	16	E	Yakima	Qa		8	67						265	Y	
20350019	11	W37273			Danny Keen		NE	SE	1	12	17	E	Yakima	Qa		6	25						220		
20350013	11	W37209			James Phillips	11607 Gilbert Road	SE	SW	2	12	17	E	Yakima	Qa		1	16						172		
20350005	11	80254			Don Reid	211 Grissom Lane	NE	SE	8	12	17	E	Yakima	Qa		4	8						225		
20350024	11				Tom Richardson		SW	SE	8	12	17	E	Yakima	Qa		3	17					8	120		
20350008	11	86480			Walt Hall	3280 Marks Road	SE	NE	9	12	17	E	Yakima	Qa		4	21						190		
20350007	11				Malcom Burke		NW	SE	9	12	17	E	Yakima	Qa		0	4						76		
20350011	11				Crosno	Station Road	SE	NE	10	12	17	E	Yakima	Qa		7	18						160		
20350012	11				Chuck Beals	12301 Rutherford Road	SE	SE	10	12	17	E	Yakima	Qa		8	16						185		
20350009	11	W50051			Irma Swalley	12907 Rutherford Road	SE	SW	10	12	17	E	Yakima	Qa		8	18						260		
20350014	11				Gary Senters	7801 Occidental	SW	SW	11	12	17	E	Yakima	Qa		11	14						225		
20350015	11	W22280			Loris Davis		NW	NW	12	12	17	E	Yakima	Qa		6	4						160		
20350017	11				Grace Shockley	9804 Meadowbrook Road	NE	SW	12	12	17	E	Yakima	Qa		7	11						160		
20350016	11	G4-25974			Enis Shockley		NW	SW	12	12	17	E	Yakima	Qa		12	41					50	300		
20350018	11	W049737			Chuck Vetsch		NW	SE	12	12	17	E	Yakima	Qa		2	15						261		
20350010	11	205600			Hanks	103 American Fruit Road	NE	NW	15	12	17	E	Yakima	Qa		14	6					14	210		
20350006	11	36487			Fred Hinze	132 Section 12 Road	SW	NW	15	12	17	E	Yakima	Qa		8	6						227	Y	
20350020	11				Brad Vetsch		SW	NE	16	12	17	E	Yakima	Qa			0						221		
20350023	11	W27395			Crawford	366 Lynch Road	NW	NE	18	12	17	E	Yakima	Qa		2	14						140	Y	
20360007	11				Shirley Hill		SE	NW	1	12	18	E	Yakima	Qa	>	6	69					4	75		
20360008	11					Ahtanum Road	NE	SE	2	12	18	E	Yakima	Qa	>	8	155					5	170		
20360009	11				Robert VanWinkle	W. Larch Avenue	NW	NW	3	12	18	E	Yakima	Qa	>	10	95						105		
20360010	11	203322			Mrs. Eno	Ahtanum Road	NW	NW	4	12	18	E	Yakima	Qa	>	1	140					37	166		
20360011	11	83547			Richard Shagen	Columbus Road	NE	NW	5	12	18	E	Yakima	Qa		11	73					48	161		
20360012	11	G4-25015			Mildred Sanger	79th Avenue	NW	NE	6	12	18	E	Yakima	Qa	>	3	117					47	120		
20360013	11	24144			Greg Gohl	Emma Lane	NE	NE	7	12	18	E	Yakima	Qa		10	80					40	152		
20360014	11	205595			Paul Morton	S. 62nd Avenue	NW	NE	8	12	18	E	Yakima	Qa		5	145					13	150		
20370072	11				Lenseigne & Sons	Moxee, WA	SW	NW	1	12	19	E	Yakima	Qfs_t		2	6					25	140	Y	
20370042	11				Larry Lenseigne	Moxee, WA	NE	SE	1	12	19	E	Yakima	Ql		10	20					15	100	Y	
20370073	11				George Zimmer	Moxee Blvd	NW	NE	2	12	19	E	Yakima	Qfs_t		9	0					8	236	Y	
20370043	11	W36574			Steve Dorais	Bell Road	NW	SE	2	12	19	E	Yakima	Ql		32	50					27	101		

IDENTIFIER						LOCATION								WELL LOG											
WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well total depth (feet)	Bedrock penetrated?	Reference
20370074	11				Nancy Malcher	Beauchene Road	N/2	SW	2	12	19	E	Yakima	Qfs_t		32	24					15	161	Y	
20370045	11	W22212			Ray Farms	Postma Road	NE	NW	3	12	19	E	Yakima	Qt		17	78					15	100		
20370044	11	211377			Ray Dixon	Beauchene Road	SW	SW	3	12	19	E	Yakima	Qt	>	9	51					9	60	N	
20370046	11				Bill Perry	Birchfield Road	NE	NE	4	12	19	E	Yakima	Qt	>	2	58					11	60		
20370047	11	W62759			Will Carector	Birchfield Road		SE	4	12	19	E	Yakima	Qt	>	4	56					6	60		
20370075	11				Golden West	Union Gap	SE	SW	5	12	19	E	Yakima	Qt	>	0	60					13	60	N	
20370064	11				Edler Pit		NE	NW	5	12	19	E	Yakima	Qa		0	80								
20370051	11	25601			United Builders	Union Gap	NE	SE	6	12	19	E	Yakima	Qa	>	4	58					9	58		
20370076	11				Easley's		NW	NW	6	12	19	E	Yakima	Qa		16	31					13	80		
20370050	11				Judy Hunter	Ahtanum Road	NW	NW	7	12	19	E	Yakima	Qa		20	32					18	98		
20370077	11				WSDOT	Union Gap	NE	SW	8	12	19	E	Yakima	Qa		17	38						100		
20370078	11				Henry Apodaca	Thorp Road	NE	SE	9	12	19	E	Yakima	Qt		15	28					6	123	Y	
20370048	11	80564			Layton's	Birchfield Road	SW	NW	10	12	19	E	Yakima	Qt	>	19	40					9	60	Y	
20370049	11				Brulotte Ranches	Scenic Drive	SE	SW	11	12	19	E	Yakima	Ql		16	42					107	1186	Y	
20370079	11				Ellen Poirier	Rivard Road	NW	NE	12	12	19	E	Yakima	Ql		34	21					20	102		
20370080	11				Wade Hull	Chappel Lane	SW	NW	13	12	19	E	Yakima	Qafo		8	0						178	Y	
20370081	11				Dean Bosler	Wapato	SW	SE	17	12	19	E	Yakima	Qa		5	28					11	115	Y	
20370082	11				Forest Baugher	Parker	SW	NW	20	12	19	E	Yakima	Qa		1	25					20	185	Y	
20370083	11				Pence Orchard	Wapato	NW	SW	20	12	19	E	Yakima	Qa		2	38					50	180	Y	
20370084	11				Stephen Randall	Parker	SW	NE	29	12	19	E	Yakima	Qa		2	10					15	160	Y	
20380008	11				J. D. Murphy	Moxee, WA	SE	SW	2	12	20	E	Yakima	Qafo		3	120					285	436	Y	
20380009	11				Rick Swain		NE	SE	6	12	20	E	Yakima	Ql		3	27					16	120	Y	
20380010	11	81077			Delmar Day		SE	NW	10	12	20	E	Yakima	Ql		2	30					114	224	Y	
20380011	11	79875			Fred DenBeste	Deeringhoff Road	N	NE	11	12	20	E	Yakima	Qafo		3	83					276	500	Y	
20390001	11				Elsie Estamo		SE	NE	10	12	21	E	Yakima	Qafo	>	2	46						48	N	
20390002	11					Moxee, WA	SW	SW	16	12	21	E	Yakima	Qafo		0	15						704	Y	
20390003	11			Livestock Well	Silvio Martinez		SE	SW	17	12	21	E	Yakima	Qafo		23	241						1551	Y	
20390004	11				Silvio Martinez		NW	SE	19	12	21	E	Yakima	Ql		9	31						803	Y	
20390005	11				Henderson		NW	NE	21	12	21	E	Yakima	Qafo		0	250						624	Y	
20390006	11				Roger Hart		NE	SW	21	12	21	E	Yakima	Ql		6	84						782	Y	
20390007	11				Harris		SE	SW	22	12	21	E	Yakima	Qafo		8	59						265	Y	
20390008	11				Simon Martinez		NE	SW	22	12	21	E	Yakima	Qafo		2	46						662	Y	
20390009	11				D. M. Fines		NW	NW	25	12	21	E	Yakima	Ql		10	15						755	Y	
20390010	11				USDA		SE	NE	27	12	21	E	Yakima	Ql		6	54						575	Y	
20400001	11				Marley Orchards		SE	SE	21	12	22	E	Yakima	Ql		12	194						904	Y	
20400002	11				Black Rock Ranch		SW	SW	22	12	22	E	Yakima	Ql		10	170						2585	Y	
19360021	11				WSDOT	S.R. 823	SW	SW	1	13	18	E	Yakima	Qa		3	66						69	Y	
19360020	11	6428363P			City of Selah		NE	NW	1	13	18	E	Yakima	Qa		0	46					6	158	Y	
19360041	11				Will Morris		SW	NW	2	13	18	E	Yakima	Mc_e		7	11								

IDENTIFIER						LOCATION									WELL LOG									
WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well total depth (feet)	Bedrock penetrated?	Reference
19360025	11	86498			Art Rosen	Galloway Street	NE	SW	4	13	18	E	Yakima	Qt		0	84					3	140		
19360024	11	37440			Hershel Strong	Maple Way	NE	NW	4	13	18	E	Yakima	Qt		13	64					15	123		
19360042	11				David Carr		NW	NE	4	13	18	E	Yakima	Qt		9	45					12	60		
19360043	11	85866			Del Cruzen	N. 37th	SW	NW	4	13	18	E	Yakima	Qt		11	86					3	157		
19360027	11	W22338			Jean Hollingberry	Cedar Hill Drive	NW	SW	5	13	18	E	Yakima	Qa	>	2	78					1	80		
19360026	11	87428			Ervin Camperer	Mitchell Drive	NW	SE	5	13	18	E	Yakima	Qa	>	1	62					5	63		
19360044	11				Ron Jones		NE	NE	6	13	18	E	Yakima	Qa		1	94					10	143		
19360028	11				Jack Walters	N. 4th Avenue	NE	SE	6	13	18	E	Yakima	Qa		6	47					30	72		
20360028	11				Earl Morton	S. 62nd Avenue	NE	SW	9	13	18	E	Yakima	Qt		7	26					82	129		
19360023	11	W04829			Frank Ketchen	Cowiche Canyon Road	NW	SE	9	13	18	E	Yakima	Qa		10	23					0	200	Y	
19360045	11	62050			Yakima Fisheries		NE	NW	9	13	18	E	Yakima	Qa		2	40					5	534		
20360032	11				Lake Aspen	Office Park	SE	SE	11	13	18	E	Yakima	Qa		0	91					28	215	Y	
19360022	11				Woodland Park	N. 1st Street	NW	SE	12	13	18	E	Yakima	Qa		7	73					0	100	Y	
20360027	11	6425698			Holiday Hotel	1st Street	NE	NE	13	13	18	E	Yakima	Qt		5	53					20	426	Y	
20360034	11				Nature Snak		SE	NW	14	13	18	E	Yakima	Qt		1	50					32	379	Y	
20360026	11				City of Yakima	River Road	NW	NE	14	13	18	E	Yakima	Qa		0	68					11	250	Y	
20360033	11	W45112			Dorhy Joaquins	Hathaway	SW	NW	14	13	18	E	Yakima	Qt		0	79					35	95	Y	
20370103	11	79658			Myron Abrams		SE	SE	16	13	18	E	Yakima	Ql		2	12					106	166		
20360025	11	7628			Joe Daves	Marsh Road	NE	SE	17	13	18	E	Yakima	Mc_e		4	36					40	204	Y	
20360029	11				Haidas Ranches	68th Avenue	NE	NE	18	13	18	E	Yakima	Qt		10	53					30	142		
20360035	11	G4-27146			Cecil Corban		SW	NW	20	13	18	E	Yakima	Mc_e		8	4					4	58		
20360036	11	G4-25006			Gary Burnham	N. 76th	NE	SW	20	13	18	E	Yakima	Rcg_t		25	25					70	115		
20360024	11	G4-28316			Dentan Association	S. Holton	SW	SW	24	13	18	E	Yakima	Qt		0	50					40	240		
20360023	11				Mobile Court	Nob Hill Boulevard	NW	SW	29	13	18	E	Yakima	Qa		3	31					13	410	Y	
20360022	11				Russ Ross	83rd Avenue	N	NE	30	13	18	E	Yakima	Qa		5	47					16	120	Y	
20360021	11				Jim Butte	80th Avenue	NE	NE	31	13	18	E	Yakima	Qt		1	54					36	114		
20360020	11				Bill Wycoff	Occidental	SE	SE	32	13	18	E	Yakima	Qa		1	59					24	76		
20360019	11				Gary Gefre	Lyon's Loop	SE	SE	33	13	18	E	Yakima	Qa		8	74					15	128	Y	
20360018	11				Bill Albano	Spring Creek Road	SE	NE	34	13	18	E	Yakima	Qa		11	92					7	130	Y	
20360017	11				Richard Ricard	S. 27th Street	NE	NW	35	13	18	E	Yakima	Rcg_t		13	74					24	130	Y	
20360016	11				Jack Harmen	S. 12th Street	SW	NW	36	13	18	E	Yakima	Qt		13	50					21	180	Y	
20360015	11				W. E. Rish		SE	SW	36	13	18	E	Yakima	Qa	>	13	93					10	105	N	
19370015	11				Selah Pit	Interstate 82	NW	NE	6	13	19	E	Yakima	Qa		0	36						40		
20370061	11	W36177			Yakima County	Terrace Heights Avenue	SW	SW	16	13	19	E	Yakima	Qt		0	78						2421	Y	
20370065	11				Ron Smith		NW	NW	17	13	19	E	Yakima	Qa		10	22								
20370066	11						NW	SE	17	13	19	E	Yakima	Qa											
20370102	11	33730			Joel Trenkenshuth		NW	NE	17	13	19	E	Yakima	Ql		4	12					16	220	Y	
20360031	11	31743			Lola Coughlin	P Street	NW	NW	18	13	19	E	Yakima	Qa		8	44					10	242	Y	

IDENTIFIER						LOCATION									WELL LOG										
WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well total depth (feet)	Bedrock penetrated?	Reference
20370056	11	G4-27921			Red Cross		NE	SW	19	13	19	E	Yakima	Qt	>	0	65					16	65	N	
20370060	11				Margarett Keyes	Keyes Road	SE	SW	21	13	19	E	Yakima	Qa	>	2	61					13	61		
20370099	11	W36538			Tim Egland	Terrace Heights Avenue	NE	NE	21	13	19	E	Yakima	Ql		6	2					70	153		
20370100	11				Duane Heath	Keyes Road	NE	SE	21	13	19	E	Yakima	Qa	>	3	57					12	60		
20370101	11	79882			Jim Evans	Terrace Heights Avenue	NE	NE	21	13	19	E	Yakima	Qa	>	0	60					12	60		
20370098	11	426340			Warrior Orchard		SE	SW	24	13	19	E	Yakima	Qafo		18	7					203	655	Y	
20370059	11					Pond Site	SE	SW	27	13	19	E	Yakima	Qa		3	69						305		
20370097	11				Rob Willet	Birchfield Road	SW	NE	27	13	19	E	Yakima	Ql		9	0					23	65		
20370096	11				Tim Egland		SW	SE	27	13	19	E	Yakima	Qt		11	19					9	90		
20370093	11					Fairgrounds	SE	NW	28	13	19	E	Yakima	Qt	>	0	153						690		
20370095	11				Harvey Fischer	Birchfield Road	SW	NE	28	13	19	E	Yakima	Qa	>	2	61					8	60		
20370094	11				Rob Allen		NW	SE	28	13	19	E	Yakima	Qa	>	2	102					10	102		
20370092	11				Greenway Park		SE	NE	29	13	19	E	Yakima	Qa		4	154						350	Y	
20370054	11				Brian Kelley	S. 13th Street	SW	SW	29	13	19	E	Yakima	Qt	>	0	100					8	100	N	
20370091	11				Laurence Moser		NW	SE	29	13	19	E	Yakima	Qt	>	1	94					12	95	N	
20370055	11	10398			James Henness	S. 8th Street	SE	NE	30	13	19	E	Yakima	Qt	>	0	86					21	77	N	
20370090	11				Mr. Lemus	S. 7th	NE	SE	30	13	19	E	Yakima	Qt	>	2	58					12	60	N	
20370052	11				Morrison Knudsen	Burlington Northern Railroad	NW	NE	31	13	19	E	Yakima	Qt	>	4	52					8	54	N	
20370089	11				Tony Riaz	S. 14th	SE	NW	32	13	19	E	Yakima	Qt	>	2	40					23	40	N	
20370053	11	R05537			WSDOT		NE	NE	32	13	19	E	Yakima	Qa	>	2	48					4	50	N	
20370088	11				Will Close	Riverside Road	NW	SE	33	13	19	E	Yakima	Qa	>	2	60					7	60	N	
20370087	11				Rich Krause	Postma Road	SE	SW	34	13	19	E	Yakima	Qt		8	46					9	59		
20370057	11	W093967			Linda Hopkins	Birchfield Road	SW	NE	34	13	19	E	Yakima	Qt		3	62					10	85	N	
20370058	11	G4-27419			Loftus Ranches		SE	SE	35	13	19	E	Yakima	Qfs$_t$		4	0						270	Y	
20370086	11				Jerry Garrison		NE	NE	35	13	19	E	Yakima	Ql		5	5					12	140		
20370085	11				John Van Belle	Roosevelt Avenue	NW	NE	36	13	19	E	Yakima	Ql		6	14					15	95		
20380012	11	205675			Donald Marklee	Moxee, WA	SE	SW	28	13	20	E	Yakima	Qafo		3	117					220	360	Y	
20380013	11	25435			Gene Clausen	Ahtanum Road	NE	SE	29	13	20	E	Yakima	Qafo		3	124					198	390	Y	
20380014	11	W36520			Mark Nelson	Miras Road	NW	NE	32	13	20	E	Yakima	Qafo		3	80					105	224	Y	
20380015	11	W49704			Bill Wolfe		SE	SE	34	13	20	E	Yakima	Qafo		1	107					285	492	Y	
19350036	11				James Yearout	Old Naches Road	NW	SW	2	14	17	E	Yakima	Qa		6	0					80	104	Y	
19350022	11	33609			George Johnson	Old Naches Road	NW	SE	3	14	17	E	Yakima	Qa		1	0					32	68	Y	
19350023	11				Daniel Razey		NE	NW	4	14	17	E	Yakima	Qa		6	32					9	61	Y	
19350024	11	W049284			Gene Pollmen	Craig Road	SW	SE	4	14	17	E	Yakima	Qa	>	0	62					9	62		
19350037	11				Will Jacobson	Briskey Lane	SE	NE	4	14	17	E	Yakima	Qa		3	12					10	40		
19350025	11	79655			Bob Stanfill	Naches Way	NW	NE	5	14	17	E	Yakima	Qa	>	0	70					9	70		
19350038	11	W44846			Chuck Harris	Old Naches Road	NE	NE	9	14	17	E	Yakima	Qa	>	2	64					10	64	N	

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19350029	11				Jim Mcphee	McPhee Lane	NE	NW	10	14	17	E	Yakima	Qa		15	21						69	Y	
19350027	11	22342			Tim Heily	Lewis Road	NW	NE	10	14	17	E	Yakima	Qa		1	63					20	110	Y	
19350028	11	10250			Rusty Lounsberry	S. Naches Road	NW	SW	10	14	17	E	Yakima	Qt	>	1	59					26	60	Y	
19350030	11				Ken Marmion	Highway 12	NE	SW	11	14	17	E	Yakima	Qa		2	38					15	90	Y	
19350039	11				Tom Vernier		SE	SW	13	14	17	E	Yakima	Qa		15	0					220	380	Y	
19350040	11				Greg Gifford	Naches Way	SE	SW	14	14	17	E	Yakima	Qt		2	53					90	372	Y	
19350041	11	W37192			Ed Markward	Englewood	SW	SE	15	14	17	E	Yakima	Qt		1	0					364	470	Y	
19350031	11				Seafirst Bank		NE	NE	23	14	17	E	Yakima	Qa		14	43					40	240	Y	
19350042	11	W40129			Morris McDowell	Old Naches Road	NW	SE	24	14	17	E	Yakima	Mc_e		6	0					320	420	Y	
19350032	11				John Moore	Kershaw Drive	NE	NW	25	14	17	E	Yakima	Qa		1	37					14	180	Y	
19350033	11				Bob Barry	S. Kershaw Road	NE	SE	25	14	17	E	Yakima	Qa		2	42					24	220	Y	
19350026	11				Hugh Townsend		SW	SE	32	14	17	E	Yakima	Qa		8	10					35	100	Y	
19350043	11	27429			Naches Fish Hatchery		SE	NE	36	14	17	E	Yakima	Qa		0	55					4	94		
19360055	11				Victor Gabband		SW	SW	4	14	18	E	Yakima	Qaf		6	24						95		
19360054	11	W06324			Steve Wakefield	7822 N. Wenas Road	SW	NW	4	14	18	E	Yakima	Ql			0						100		
19360053	11	W04026			Mayo Cattle Company		NE	SE	5	14	18	E	Yakima	Ql		8	15						460		
19360056	11	7646			Victor Gabbard	S. Wenas Road	NE	NE	9	14	18	E	Yakima	Qaf			0						184		
19360057	11	83984			David Cardinas	S. Wenas Road	NE	SE	10	14	18	E	Yakima	Qa		5	17						172	Y	
19360058	11				Price		NW	SW	11	14	18	E	Yakima	Qa		6	16						201	Y	
19360059	11				Bill Guthrie		NW	SE	12	14	18	E	Yakima	Qa		2	14						150		
19360047	11				Pat Cole		NW	NW	25	14	18	E	Yakima	Qt		7	0					45	150		
19360046	11				Allen Scherzinger	Harrison Heights	NE	NE	25	14	18	E	Yakima	Qt		6	32					60	106	Y	
19360035	11	205702			Charles Goertler	Cutler Way	NW	SE	25	14	18	E	Yakima	Qt		2	22					29	138		
19360048	11				Burl Van Zandt	Wenas Road	NE	SW	25	14	18	E	Yakima	Qa		4	0					35	160		
19350035	11	7344			Eastern Fruit	Lower Naches Road	E/2	SW	30	14	18	E	Yakima	Qa		0	75					11	207	Y	
19350020	11	G4-27261			Price Cold Storage		SE	SW	30	14	18	E	Yakima	Qa	>	0	58					14	239		
19360032	11				Ronald Young	Hadley Drive	NW	SE	30	14	18	E	Yakima	Qt		17	44					17	85		
19350034	11	G4-27857			Yakima Valley Orchards	Allen Road	SW	NW	30	14	18	E	Yakima	Qa		1	27					69	205	Y	
19360029	11	6426959			Northwestern		SE	NE	31	14	18	E	Yakima	Qa		7	81					6	440	Y	
19350021	11				R. S. Johnston	Laughlin Road	NE	NW	31	14	18	E	Yakima	Qa	>	0	55					35	85	N	
19360030	11				Millard	Urban Lane	NW	NE	32	14	18	E	Yakima	Qt	>	12	48								
19360031	11				Birch Circle Community		SW	NW	32	14	18	E	Yakima	Qa		6	90					10	97		
19360050	11				Evelyn Bogari	Donelson Lane	SW	NW	33	14	18	E	Yakima	Qt		0	45					26	102	Y	
19360049	11				John Taylor	Moonlight Lane	NW	NE	33	14	18	E	Yakima	Qa		6	0					285	445	Y	
19360051	11				Mary Clark		NW	NW	35	14	18	E	Yakima	Mc_e		6	8					85	166	Y	
19360033	11	G4-27442			Larsen Fruit		SW	NW	36	14	18	E	Yakima	Qt		1	36					80	320		

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19360034	11				Matson Fruit		NE	SW	36	14	18	E	Yakima	Qa		8	32						382		
19370017	11				Selah Pit	Interstate 82	SE	SE	30	14	19	E	Yakima	Qa		0	37						51		
19360038	11						NW	SW	31	14	19	E	Yakima	Qa		0	30								
19370016	11				Selah Pit	Interstate 82	NW	SE	31	14	19	E	Yakima	Qa		0	39						45		
18330016	11				Carla Jaeger	Nile Road	SE	NW	3	15	15	E	Yakima	Qa		8	49					10	150	Y	
18330015	11				Dick Griffin	Highway 410	SE	NE	11	15	15	E	Yakima	Qa		3	39					30	148	Y	
18330017	11				Dianne Simmons	Nile Road	NW	SW	11	15	15	E	Yakima	Qa		4	22					26	72	N	
19340009	11				Keith Hole	Highway 12	NE	SW	36	15	16	E	Yakima	Qa		0	22					7	85	Y	
18350009	11	10935			Perry Lance		SW	SW	12	15	17	E	Yakima	Qa		0	12						550	Y	
18350010	11				Mike Sansilo		NW	NE	13	15	17	E	Yakima	Qa			0						637		
18350011	11				Hargrades		NE	SE	13	15	17	E	Yakima	Qa		12	12						657	Y	
18350013	11				Jenkins		SE	NE	24	15	17	E	Yakima	Qa			0						214		
18350014	11	W093889			David Stanley		NE	SE	25	15	17	E	Yakima	Qa		2	21						304	Y	
18350012	11	85876			Lyle Schnider	Wenas Road	NW	NW	19	15	18	E	Yakima	Qaf			0						360		
18360003	11	85763			Craig Nedrow	10081 N. Wenas Road	NE	SW	29	15	18	E	Yakima	Qa		3	12						375		
18360002	11	25582			Fusner	10680 N. Wenas Road	N	NE	30	15	18	E	Yakima	Qa			0						160		
19360052	11	W104779			Donald Wilfong	5321 S. Wenas Road	SE	SE	31	15	18	E	Yakima	Ql		26	21						120		
18330011	11				Dick Weeler	Nile Road	NW	NE	28	16	15	E	Yakima	Qa		2	28					43	170	Y	
18330012	11				Lois Armstrong	Deerview Lane	SW	NE	28	16	15	E	Yakima	Qa		3	37					20	120	Y	
18330014	11				Larry Glover	Highway 410	NE	SW	34	16	15	E	Yakima	Qa		3	30					5	52	N	
18330013	11				C. S. Carlisle	Nile Road	SW	SW	34	16	15	E	Yakima	Qa		2	20					22	284	Y	
17350017	11	10471			Martin Dyk		NE	NW	1	17	17	E	Kittitas	Qa			0						200		
17350018	11	W086596			Hagbow	Weaver Road	NE	NE	1	17	17	E	Kittitas	Qa			0						138		
17350019	11	W089657			Bob Belsaas		SE	SW	12	17	17	E	Kittitas	Qa			0						85	Y	
17350012	11	W50961			Kenneth Harris		SW	NW	12	17	17	E	Kittitas	Qa		2	27						220	Y	
17350013	11	85854			John Smith	Cove Road	E	NE	12	17	17	E	Kittitas	Qa		6	24						228	N	
17350010	11	W50949			Bill Houston		SE	SE	12	17	17	E	Kittitas	Qa		2	40						233		
17350009	11	W089726			Merrill-Steskal		NW	NE	13	17	17	E	Kittitas	Qa		2	37						261	Y	
17350008	11				Horace Ferguson	Manastash Road	NW	NW	14	17	17	E	Kittitas	Qa		0	12						85	Y	
17350007	11				Cliff Gage		NE	NE	15	17	17	E	Kittitas	Qa		0	18						100	Y	
17360046	11				City of Ellensburg		NE	NW	1	17	18	E	Kittitas	Mc_e		0	32					29	761	Y	
17360047	11				Byron Thomas		SW	NE	2	17	18	E	Kittitas	Qt		0	205					30	240	Y	
17360048	11	W039248			R. Hodges		SW	SW	2	17	18	E	Kittitas	Qa	>	16	164					51	180		
17360050	11	W109572			Norm Butler		SW	NW	4	17	18	E	Kittitas	Qt	>	3	122					28	123		
17360049	11	W45104			Josh Nelson		NW	NW	4	17	18	E	Kittitas	Qt	>	1	57					25	73		
17360052	11	W092851			Roger Matteson		NW	SE	4	17	18	E	Kittitas	Qt		3	132					35	160		
17360051	11	7382			Buck Hart		NE	SE	5	17	18	E	Kittitas	Qt		24	201					95	405	Y	
17350016	11	W092886			Jim Andrews		NE	SW	6	17	18	E	Kittitas	Qt		28	32						200	Y	
17350011	11	W062861			Jody Louise	5650 Cove Road	SW	SW	7	17	18	E	Kittitas	Qa		5	18						282		

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WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well total depth (feet)	Bedrock penetrated?	Reference
17350014	11	W109565			Louis Tasker		NW	NW	7	17	18	E	Kittitas	Qa			0						205		
17350015	11	W50986			Jim Smith		NE	NE	7	17	18	E	Kittitas	Qa		2	30						135		
17360054	11	W089653			Clay Thayer		SE	NE	8	17	18	E	Kittitas	Qt	>	3	99					33	100		
17360055	11				Dan Kivy		SE	SW	8	17	18	E	Kittitas	Qt	>	5	134					22	139		
17360053	11	27426			Donna Berto		NW	NW	8	17	18	E	Kittitas	Qa		6	132					52	140		
17360057	11	58312			Bart Bland		SW	SW	9	17	18	E	Kittitas	Qt	>	6	74					54	157		
17360056	11	80347			Allen Gayken	Brundt Road	NE	NE	9	17	18	E	Kittitas	Qt	>	3	70					18	102		
17360058	11	89702			Par Five Inc.		NE	NE	10	17	18	E	Kittitas	Qa	>	3	82					4	85		
17360061	11	W079084			Fred Keaton	Anderson Road	NW	NW	10	17	18	E	Kittitas	Qa	>	2	78					3	80		
17360059	11	33611			Rich Hadden		S	NW	10	17	18	E	Kittitas	Qt		2	155					40	160		
17360060	11	33617			Dammon School	Dammon Road	SW	SE	10	17	18	E	Kittitas	Qt		4	188					30	202		
17360064	11	87970			David Hall		SW	SE	13	17	18	E	Kittitas	Qa	>	5	95					6	100		
17360062	11				Merle Schmith		SW	N	13	17	18	E	Kittitas	Qa		0	140					20	150		
17360063	11	W050987			Andy Dyk		SW	SW	13	17	18	E	Kittitas	Qa	>	11	70					22	81		
17360040	11	W092877			Chip Carr		NW	NE	6	17	19	E	Kittitas	Qa		15	0					38	260	Y	
17360041	11	87490			Jim Applegate	Kittitas Highway	SW	SE	6	17	19	E	Kittitas	Qa		4	15					5	60		
17360042	11	28692					NW	NE	7	17	19	E	Kittitas	Ql		5	15					15	100	Y	
17360043	11	48341			Evan Scheik	Woodhouse Road	NW	NW	19	17	19	E	Kittitas	Qa	>	6	74					6	80	N	
17360044	11	31744			John Wright	Thrall Road	SE	SW	30	17	19	E	Kittitas	Qa		4	15					0	130	Y	
17360045	11	3762			Joyce Muniguin		NW	NE	31	17	19	E	Kittitas	Qa		3	0					0	120	Y	

Appendix 6. Geologic descriptions of significant and (or) historically mined units

This appendix includes unit descriptions for geologic units that have been mined for construction aggregates and (or) that have potential to produce gravel or bedrock meeting the threshold criteria of this study. These descriptions are intended for geologists and engineers and contain a number of terms that are not included in the glossary (Appendix 1). For complete descriptions of all geologic units in the Yakima quadrangle, the reader is referred to Walsh (1986) and Schuster (1994).

SAND AND GRAVEL UNITS

Qa — **Alluvium (Holocene)**—Unconsolidated deposits of gravel, sand, silt, and clay along flood plains of rivers and creeks and in valley bottoms. Gravel and sand deposits dominate along rivers, while sand, silt, and clay dominate along smaller creeks. This unit also contains interbedded tephra lenses derived from late-Quaternary Cascade eruptions, such as the Mazama and Mount St. Helens tephras. (Description compiled from Bentley and others, 1980.)

Qt — **Terrace deposits (Holocene to Pleistocene)**—Three distinct terrace deposits present throughout the Yakima quadrangle. The terraces are associated with sediment influxes to the Yakima River as a result of glaciation during the Pliocene and Pleistocene. Campbell (1983) divided the deposits into lower, middle, and upper levels at 16, 30, and 200 feet (5, 10, and 60 meters), respectively, above the current flood plain. (Description compiled from Campbell, 1983.) In this study, only the lower terrace and parts of the middle terrace were identified as possible future gravel resources. The clasts of the upper terrace generally are highly weathered and cemented (Campbell, 1983) and thus would probably not meet the threshold criteria of this inventory.

Qaf, Qafo — **Alluvial fan (Holocene to Pleistocene)**—Fluvial clay, silt, sand, and gravel generally derived from rapid runoff and flash flooding. Clasts are typically angular to subangular and poorly sorted. (Description compiled from Campbell and Gusey, 1992.) Small borrow pits are common within these fan deposits, but the unit is generally considered a poor gravel resource and not economically viable for large-scale mining operations.

QꝐcg — **Continental sedimentary deposits or rocks, conglomerate (Pleistocene to Pliocene)**—Alluvial fan and terrace remnants consisting of coarse sand and gravel with local fine sand and silt lenses. Clasts are dominantly basalt. The unit is slightly to moderately weathered and is associated with steep slopes of anticlinal ridges. The age of this unit is uncertain, but it may be in part correlative with Thorp Gravel. (Description compiled from Walsh, 1986.) No strength or durability testing has been performed on this unit, and it is not considered a significant resource.

Ꝑcg$_t$ — **Thorp Gravel (Pliocene)**—A weakly cemented, deeply weathered gravel unit that unconformably overlies the Ellensburg Formation. The Thorp Gravel is divided into two facies: the mainstream facies and the sidestream facies. The mainstream facies consists of subrounded to rounded chert and durable silicic to intermediate volcanic clasts. Gravels of the mainstream facies along the axis of the Yakima River are included in this inventory. Well logs examined near the Yakima River in the Kittitas Valley indicate that a thick sequence of mainstream gravels underlies the modern Yakima River flood plain to a depth of 200 feet. The sidestream facies consists of angular to subrounded cobbles composed entirely of basalt derived from the Columbia River Basalt Group. Sidestream facies terraces occur widely throughout the quadrangle, but none of these deposits are included in the inventory because the clasts typically have thick weathering rinds, are heavily oxidized, and are cemented in a clay matrix. (Description compiled from Waitt, 1979.)

Mc$_e$ — **Ellensburg Formation, undivided (upper and middle Miocene)**—Weakly to moderately indurated fluvial and laharic deposits consisting of gravel, sand, silt, and clay. These white to light red-brown deposits are dominated by pumiceous dacitic, andesitic, and basaltic clasts. The base of the Ellensburg Formation is defined as the top of the locally lowermost flow of Columbia River Basalt Group, but the unit includes all conformably underlying sediments of similar lithology beyond the edge of lowermost basalt flow. The top of the unit is defined as the base of the Thorp Gravel or other Pliocene(?)–Pleistocene units. To the east, this unit intertongues with flows of the Columbia River Basalt Group. (Description compiled from Walsh, 1986.) Many small borrow pits are located within this unit, but because the clasts are highly weathered and weak, this deposit is not considered a gravel resource. However, some of the coarse sand layers within this unit may be useful as blending sand if combined with coarse aggregate from another unit.

BEDROCK UNITS

Tieton Andesite

Qva$_{ti}$ — **Tieton Andesite (Pleistocene)**—Phyric hypersthene augite andesite, approximately 1 million years old. This unit is dark gray with abundant plagioclase phenocrysts and some minor tephras. The Tieton Andesite originated near the Goat Rocks area, and the one flow on the Yakima quadrangle reached the area near the Naches River–Yakima River confluence. This intercanyon flow averages 100 feet thick and underlies Naches Heights. (Description compiled from Campbell and Gusey, 1992.) This rock is extremely hard and durable and is considered a significant resource.

Columbia River Basalt Group

SADDLE MOUNTAINS BASALT

Mv_{s} **Saddle Mountains Basalt, undivided (upper and middle Miocene)**—The youngest formation of flows in the Columbia River Basalt Group. It contains ten members (Bentley and others, 1980), six of which crop out in the Yakima quadrangle (Schuster, 1994; Walsh 1986). This rock is extremely hard and durable and is considered a significant resource.

Mv_{sem} **Elephant Mountain Member (upper Miocene)**—Single fine-grained, normal to transitionally magnetized basalt flow that is aphyric to sparsely plagioclase-phyric. Black to blue-black on a fresh surface, the unit weathers gray. The flow is usually less than 50 feet thick and has a relatively short colonnade with many vesicle sheets. The unit crops out on the Rattlesnake Hills, southeast of Elephant Mountain. (Description compiled from Bentley and others, 1980; Schuster, 1994.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{sp} **Pomona Member (middle Miocene)**—Single fine- to medium-grained, reversely magnetized basalt flow with scattered plagioclase phenocrysts. Gray to blue-black on a fresh surface, the unit weathers gray. The flow is usually 180 feet thick and typically has small, fanning columns in the entablature and is often underlain by the Selah Member of the Ellensburg Formation in the Yakima quadrangle. The unit crops out on southern side of Umtanum Ridge near Selah Butte, on Yakima Ridge, and in the Rattlesnake Hills. (Description compiled from Bentley and others, 1980; Schuster, 1994; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{se} **Esquatzel Member (middle Miocene)**—Single fine-grained, normally magnetized basalt flow that is sparsely phyric with plagioclase and clinopyroxene phenocrysts and glomerocrysts less than 5 millimeters across irregularly distributed in flow. Blue-black on a fresh surface, the unit weathers gray. This unit is an intercanyon flow that crops out near Selah Butte on Yakima Ridge. (Description compiled from Bentley and others, 1993; Schuster, 1994.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{sa} **Asotin Member (middle Miocene)**—Single fine-grained, normally magnetized basalt flow that is sparsely plagioclase-phyric. Blue-black on a fresh surface, the unit weathers gray. This unit is an intercanyon flow that crops out on Yakima Ridge. This basalt flow is also known as the Huntzinger Flow. (Description compiled from Bentley and others, 1993; Schuster, 1994; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{swc} **Wilbur Creek Member (middle Miocene)**—Single fine-grained, normally magnetized basalt flow that is aphyric with plagioclase microphenocrysts and rare phenocrysts. Black to blue-black on a fresh surface, the unit weathers gray-black. The unit crops out as an intercanyon flow along Yakima Ridge, south of the Yakima Training Center. (Description compiled from Bentley and others, 1993; Schuster, 1994; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{su} **Umatilla Member (middle Miocene)**—Single fine-grained or rarely medium-grained, normally magnetized basalt flow that is aphyric to very sparsely plagioclase-phyric. Black to blue-black on fresh surfaces, the unit weathers gray to red-orange. The flow is usually 100 feet thick and crops out on Ahtanum Ridge, in the Rattlesnake Hills, and as an intercanyon flow on Yakima Ridge. (Description compiled from Bentley and others, 1993; Schuster, 1994.) This rock is extremely hard and durable and is considered a significant resource.

WANAPUM BASALT

Mv_{w} **Wanapum Basalt, undivided (middle Miocene)**—The middle formation of flows in the Columbia River Basalt Group. It contains four members, three of which crop out in the Yakima quadrangle (Schuster, 1994; Walsh, 1986). This rock is extremely hard and durable and is considered a significant resource.

Mv_{wpr} **Priest Rapids Member (middle Miocene)**—Two medium- to coarse-grained, reversely magnetized basalt flows that are diktytaxitic and aphyric with rare plagioclase and olivine phenocrysts. Gray-black on fresh surfaces, the unit weathers rusty brown. The member is usually 200 feet thick and the flows have well-developed colonnades with 1.5- to 5-foot diameter columns. This unit crops out on Yakima Ridge and within the Yakima Training Center. (Description compiled from Bentley and others, 1980; Bentley and others, 1993; Schuster, 1994; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{wr} **Roza Member (middle Miocene)**—One or two fine- to medium-grained, normally magnetized basalt flows that have abundant plagioclase phenocrysts and glomerocrysts and are locally diktytaxitic. Gray-black on fresh surfaces, the unit weathers reddish brown. The member is usually 85 feet thick, and the flows usually have a well-developed colonnade with columns up to 3 feet in diameter. The member crops out mainly in the eastern half of the quadrangle and on Yakima and Umtanum Ridges. (Description compiled from Bentley and others, 1980, 1993; Schuster, 1994; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{wfs} **Frenchman Springs Member (middle Miocene)**—Six fine- to medium-grained, normally magnetized basalt flows usually with moderate to abundant plagioclase phenocrysts, but some flows are aphyric or sparsely phyric. Gray to black on fresh surfaces, the unit weathers from gray to reddish brown. This unit crops out throughout entire area and covers most of the eastern third of the quadrangle. (Description compiled from Bentley and others, 1980, 1993; Schuster, 1994; Schuster and others, 1997; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

GRANDE RONDE BASALT

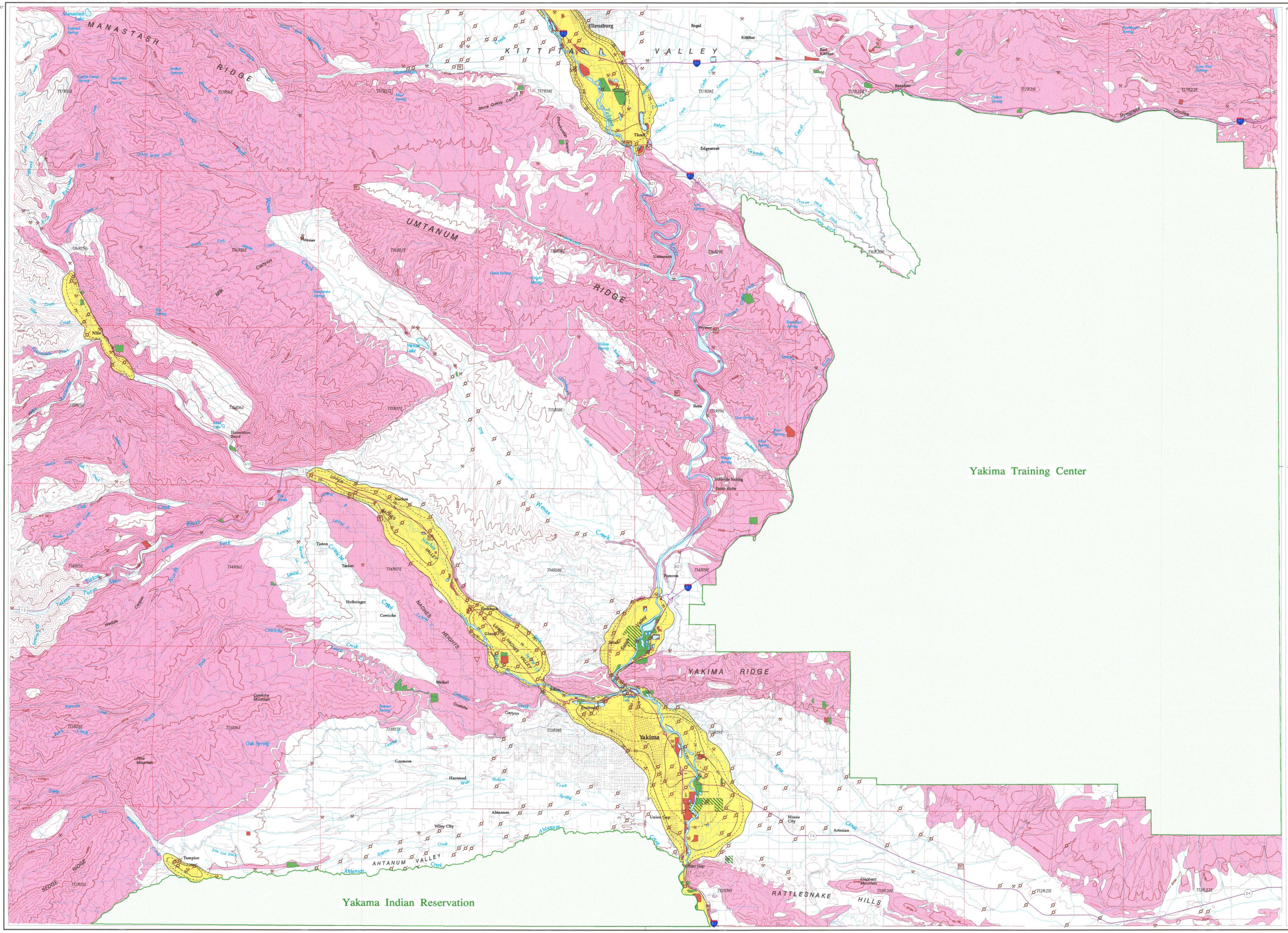
Mv_{gN2} **Grande Ronde Basalt, upper flows, normal polarity (middle Miocene)**—Four or five mostly fine-grained, normally magnetized basalt flows that are aphyric. Dark-gray to black on fresh surfaces, the unit weathers reddish brown or gray. This unit frequently crops out on the western half of the map and covers the largest surface area of any Columbia River Basalt Group member in the Yakima quadrangle. (Description compiled from Bentley and others, 1980, 1993; Schuster, 1994; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{gR2} **Grande Ronde Basalt, upper flows, reversed polarity (middle Miocene)**—Three to six usually fine-grained with some medium- and coarse-grained reversely magnetized basalt flows that are aphyric. Black to gray-black on fresh surfaces, the unit weathers reddish gray to grayish black. Each flow averages approximately 85 feet thick and contains poorly developed colonnade and entablature zones. This unit crops out on the western half of the Yakima quadrangle. (Description compiled from Bentley and others, 1980, 1993; Schuster, 1994; Walsh, 1986; Campbell and Gusey, 1992.) This rock is extremely hard and durable and is considered a significant resource.

Mv_{gN1} **Grande Ronde Basalt, lower flows, normal polarity (middle Miocene)**—Multiple, mostly fine-grained, normally magnetized basalt flows that are aphyric. Dark gray to black on fresh surfaces, the unit is iron-stained and has a pale green color when weathered. This unit crops out where Ahtanum Creek cuts into Sedge Ridge. (Description compiled from Bentley and others, 1980; Campbell and Gusey, 1992; Walsh, 1986.) This rock is extremely hard and durable and is considered a significant resource.

Fifes Peak Formation

Mva_{fp} **Fifes Peak Formation (lower Miocene)**—The Edgar Rock cone facies and the Edgar Rock apron facies of the Fifes Peak Formation crop out along the western margin of the Yakima quadrangle. The cone facies consists of basaltic and andesitic lava flows and breccias. The flows, which include a radial swarm of andesite dikes, are dark gray to black and are phyric with plagioclase phenocrysts. The apron facies consists of andesitic and basaltic breccias, tuffs, lahars, and fluvial slurries. (Description compiled from Campbell and Gusey, 1992.) This soft, crumbly facies contributes to the massive landslides found on the western margin of the quadrangle. While there are a few borrow pits in this unit, the majority of the unit is composed of very poor quality rock, therefore it is not considered a significant resource.



Washington Division of Geology and Earth Resources
Raymond Lasmanis, State Geologist
Information Circular 92
April 2001

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

PLATE 1

RECONNAISSANCE INVESTIGATION OF SAND, GRAVEL, AND QUARRIED BEDROCK RESOURCES IN THE YAKIMA 1:100,000 QUADRANGLE, WASHINGTON

Kevin D. Weberling, Andrew B. Dunn, and Jack E. Powell

with digital cartography by
Charles G. Caruthers, Phung Ho, and Anne Heinitz

EXPLANATION

- Location of water well used in this study for subsurface information
- Location of geotechnical or other borehole used in this study
- Sampling site for laboratory test of strength and durability of gravel or rock. (Does not include analyses from most mines. These are described in Appendix 4)
- Small gravel pit, borrow pit, or quarry. Most of these mines are used for forest road maintenance or construction and/or do not significantly influence the market at this time
- Depleted or abandoned small gravel pit, borrow pit, or quarry. Includes mines with terminated state reclamation permits, reclaimed sites, and mines that cannot be operated owing to changes in land use (for example, if the site has been flooded by a reservoir)
- Large active mine. Includes intermittently operated sites and a few sites that may have been abandoned, but not reported as such
- Large depleted or abandoned mine
- Large proposed mine
- Potential extent of 'hypothetical undiscovered' sand and gravel reserves, most of which meet threshold criteria for strength, durability, thickness, areal extent, and clast-size distribution, and are not buried under thick layers of overburden. (See text for further explanation)
- Potential extent of 'speculative undiscovered' bedrock reserves, most of which meet threshold criteria for strength, durability, thickness, and areal extent, and are not buried under thick layers of overburden. (See text for further explanation)
- Contour showing possible thickness of some hypothetical gravel deposits meeting the threshold criteria (50-ft interval, half contours dashed) Contours within mine boundaries are not shown due to map scale (See Appendix 3 for approximate mine reserves)

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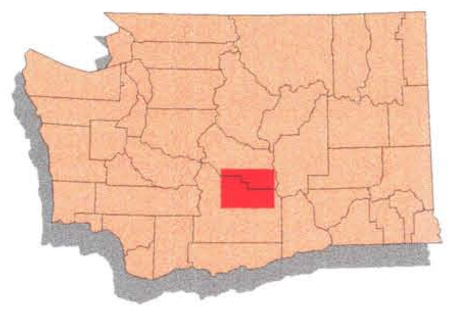

0 1 2 3 4 5
MILES

Scale 1:100,000

TOPOGRAPHIC CONTOUR INTERVAL 200 FEET

Lambert Conformal Conic Projection
1927 North American Datum
Washington State Plane Coordinate System, South Zone
Other base map information from the Washington Department of Natural Resources, Geographic Information System Database - 2000
Washington Division of Geology and Earth Resources